

3.4. Aquatic, Riparian, and Meadow Ecosystems

Affected Environment

The Sierra Nevada Science Review (USDA Forest Service, 1998c) identified aquatic, riparian and meadow ecosystems as priority issues for Sierra Nevada conservation. The Science Review further delineated four habitat regions within these ecosystems as specific elements that could be addressed by changes in Forest Service management. The four elements were: 1) low to mid-elevation ecosystems, 2) high elevation ecosystems, 3) frog and toad habitat, and 4) willow flycatcher habitat.

There were many factors that led the Science Review to conclude that aquatic, riparian and meadow ecosystems should be priorities for conservation. A synopsis of these factors follows.

Of 66 types of aquatic habitat mapped in the Sierra Nevada Bioregion, 73 percent are declining in quality and abundance, and many are at risk of disappearance (Moyle 1996a). Approximately 50 percent of these habitats are found at elevations that might occur on National Forest System land. Nineteen habitats occur in low to mid elevations, 15 of which were identified in moderate decline. Similarly, 31 are located in alpine areas, 15 of which were found to be in moderate decline.

Of 40 native fish species found in the Sierra Nevada, nine are formally listed, 9 are candidates, and four are in serious decline (Moyle and others 1996a). Declines in golden trout are associated with hybridization, competition, and predation by introduced fish in native trout habitat (Knapp 1996). Thirty nonnative fish species have become established in Sierra Nevada lakes and streams due to stocking.

Information in the California Water Plan Update (CA DWR, 1998) shows that dams and diversions are found on most Sierra Nevada rivers and streams. Only three rivers greater than 100 miles long (Clavey, Middle Fork Cosumnes, and South Fork Merced) are free flowing. Of these three rivers only the Cosumnes is free flowing to the Pacific Ocean, although one of its tributaries (Sly Park Creek) is dammed to provide water diversions for local irrigation. Other than the Cosumnes River, only small creeks in the upper Sacramento River watershed currently allow native anadromous fish stocks to migrate into their historic Sierra Nevada habitat.

Degradation of riparian and aquatic habitat and biodiversity has been linked to forest management activities, dams and diversions, mining, and overgrazing (Moyle and others 1996a, Kattleman 1996). Local disturbances that increase sedimentation of aquatic habitats appear to have significant impacts on the diversity of aquatic invertebrates (Erman 1996, Roby and Azuma 1995, McGurk and Fong 1995) and on fish spawning habitats (Moyle and others 1996).

Over 50 percent of the 30 native Sierra Nevada amphibian species have experienced population declines and are in need of protection to survive. The most at-risk species are closely tied to aquatic and riparian habitats, and include the true frogs (*Rana* spp.) and toads (*Bufo* spp.) (Jennings 1996).

Periodic surveys in recent decades have indicated continuing declines of willow flycatchers (*Empidonax traillii*) throughout their entire range. Declines are believed to be related to direct degradation of nesting and foraging habitat from livestock grazing in meadows (Graber 1996) and loss of riparian habitat (Harris and others 1987).

The “Species of the Sierra Nevada” section of this document (Chapter 3, Part 4) provides detailed information on the affected environment for aquatic, riparian and meadow dependent species as well as the environmental consequences to these species of implementing the alternatives. The following section on aquatic, riparian and meadow ecosystems, will discuss the physical environment and factors that affect them.

Streams and Rivers

Water Supply. Water is one of the most important and valuable resources originating in the Sierra Nevada. Water accounts for over 60 percent of the \$2.2 billion worth of commodities and services produced annually by Sierra Nevada ecosystems. Hydropower users account for 40 percent of the total economic value of water, irrigated agriculture accounts for 34 percent, and municipal water accounts for 20 percent. The recreational value of water is difficult to measure accurately because few direct fees are collected. Recreational fishing and whitewater rafting, however, have a value in excess of \$250 million (Stewart 1996). In addition, millions of dollars annually support water treatment facilities to protect and maintain high water quality.

According to the California Water Plan Update (CA DWR 1998) the SNFPA area is encompassed by five major hydrologic regions. Three regions are on the westside of the Sierra Nevada crest (the Sacramento River, the San Joaquin River, the Tulare Lake basin); the North and South Lahontan regions are on the eastern side. The average annual unimpaired flow from the west slope is 33.6 million acre feet; unimpaired flow from the east slope is 3.2 million acre feet. Agricultural uses consume about 65 percent of the total flow, 17 percent is used in urban areas, and 18 percent goes to environmental uses including wildlife refuges and instream flow requirements for fisheries or wild and scenic rivers.

Water storage, diversion, and delivery are key components to the success of supplying water within California. California is the Nation’s leading agricultural state, producing 45 percent of the Nation’s fruits and vegetables as well as many other agricultural commodities. Most population centers and much of the irrigated farmlands are not located near the water sources and rely on storage and delivery systems to supply water for agricultural, domestic and industrial needs. This point illustrated by Table 3.4a, shows total unimpaired supply, current agricultural use by hydrologic region, and population levels in 1995 and those projected for 2020. (CA DWR 1998)

Table 3.4a shows total unimpaired supply, current agricultural use by hydrologic region, and population levels in 1995 and those projected for 2020. (CA DWR 1998)

Hydrologic Region	Average Annual Unimpaired Flow (million acre-feet)	1995 Irrigated Acreage (Thousands)	1995 Agricultural Water Use (million acre-feet)	Population 1995 (thousands)	Population 2020 (thousands)
Sacramento River	22.4	2,087	8,065	2,372	3,813
San Joaquin River	7.9	1,949	7,027	1,592	3,025
Tulare Lake basin	3.3	3,064	10,736	1,738	3,296
North Lahontan	1.9	161	530	84	125
South Lahontan	1.3	61	332	713	2,019
Total State	70.8	9,068	33,780	32,060	47,510

California is the Nation’s most populous state; 1 in 8 Americans live here. By the year 2020, the population of California is expected to increase by 15.4 million individuals, equal to the current total population of all of the other states west of the continental divide excluding Colorado and Washington. Between 1970 and 1990, the human population of the Sierra Nevada doubled to

approximately 908,000; the current population is projected to triple by 2040. These trends will result in greatly increased future demand for water and water-associated resources. The California Department of Water Resources predicts a shortfall of water supplies of 2 million acre feet per year in normal water years up to a shortfall of nearly 6 million acre feet per year in critically dry years (drought years equivalent to the 1976/77 drought period) by 2020. (CA DWR 1998).

To address the disparity between water supply and water use locations, two major water storage and diversion systems were developed in California: the Federal Water Project managed by the Bureau of Reclamation and the State Water Project, managed by the California Department of Water Resources. Both rely on an extensive system of dams and diversions to store and route water primarily from Sierra Nevada streams to Central Valley, San Francisco Bay Area, and Southern California water consumers. Several state and federal programs are currently assessing ways to address California's increasing water needs while minimizing impacts to environmental resources dependent on natural stream flows and habitats.

Miners built many dams and diversions originally in the 1850's to provide a water source for sluicing and hydraulic mining. Many local foothill water districts have expanded and upgraded these mining facilities and rely on them for local water supplies.

The influences of the management actions proposed in the alternatives in this FEIS on riparian, aquatic, and meadow ecosystems are relatively small compared to effects caused by historical activities, particularly dams and diversions, and historic mining practices. It is important to separate historical influences from the effects of actions that are proposed under the alternatives. Chief among these historical activities, but still having a major influence is dams and diversions and their operations

Of all the human caused impacts to aquatic, riparian, and meadow ecosystems in the Sierra Nevada those caused by dams and diversions are the most widespread. Dams and diversions have altered the connectivity of streams and changed downstream flow patterns. Many dams permanently inundate vast areas of historic riparian and meadow habitats with reservoirs. In many cases this has resulted in negative changes in the biotic community.

The dams and reservoirs in the Sierra Nevada are largely impenetrable barriers for anadromous fish, and unsuitable habitat for species evolved to inhabit free-flowing, well-oxygenated water with coarse bottom substrates. Kondolf and others (1996) evaluated the distribution of reservoirs in the Sierra Nevada and found that they had created more than 150 spatial gaps in riparian areas greater than 0.3 miles long and eliminated at least 620 miles of riparian corridors for species travel. They also selected 130 watersheds between 10,000 and 50,000 acres in size to assess riparian canopy continuity. They found that 93 percent of the watersheds showed gaps mainly from road and railroad crossings, timber harvesting, dams and diversions, livestock grazing, and vegetation removed from private property.

The most noted example of deleterious effects by dams and diversions to fisheries in the Sierra Nevada is the decline of anadromous fish stocks, especially spring run Chinook salmon and steelhead. These two species historically spawned in headwater streams high in the Sierra Nevada. Very few dams allow anadromous fish to pass upstream, and currently, only a few streams on the Lassen National Forest and the Cosumnes River on the Eldorado National Forest support natural spawning runs of these species. Moyle and others (1996a) stated that dams on major rivers block access by

spring-run Chinook salmon to more than 95 percent of its spawning and holding areas. Dams have greatly reduced access to spawning grounds historically used by salmon, steelhead, and Pacific lamprey.

Dam construction during the past century has also changed the movement of large woody debris throughout stream channel networks in the Sierra Nevada. With dams, stream flows are generally more constant and floods are fewer. Historically, floods distributed large woody debris downstream. Small and moderate peak flows seldom move this large woody debris, and the role of moving debris has shifted to large infrequent floods when reservoirs discharge excess water.

Controlled water releases from dams determine streamflows, and influence water quality, water temperature, and sediment regimes for considerable distances downstream. Streamflow regimes in many major Sierra Nevada rivers and streams have been greatly altered to provide water storage for economic and social needs. The alternatives in this FEIS would not affect the operations of existing dams. However, application of the goals of the Aquatic Management Strategy may influence future relicensing efforts to ensure adequate instream flows and habitat requirements are provided for species influenced by dams.

Water Quality. People expect water of high quality from the national forests in the Sierra Nevada. Most of the time this expectation is met. High quality water is necessary to provide for beneficial uses such as municipal water supplies, agriculture, recreation, hydroelectric power, and to provide instream flows for aquatic and riparian ecosystems. Water of sufficient quality to provide suitable conditions for coldwater fish generally meets the conditions required for other uses. The robust functioning of riparian and upland ecosystems links directly to satisfactory water quality.

High water quality is a critical habitat element for many species in riparian and aquatic ecosystems. The quality of water depends on many variables. The variables most strongly tied to forested landscapes include water temperature, turbidity, and chemical and nutrient concentrations. These elements interact in complex ways to influence distribution, patterns of abundance, growth, reproduction, and migration of aquatic organisms. For example, sediment alone is not lethal to fish (Cordone and Kelley 1961), but fine sediments deposited on a streambed may disrupt substrate habitats for their food supply, aquatic insects, and result in fish population declines. Fine sediments can disrupt spawning, smother egg masses, or disrupt the development of larvae. Extremes of water temperature affect the type, quantity, and health of plants and animals within aquatic systems. Increases in summertime stream temperature are often cumulative as water moves downstream through watersheds.

The Sierra Nevada region generally produces surface water of excellent quality, suitable for almost any use. Contaminant levels in most waters are lower than amounts specified in the States of California and Nevada stream quality standards (Kattelmann 1996). Most runoff would be suitable as drinking water except for the risk of bacteria and pathogens, such as *Giardia lamblia*, *Campylobacter* spp., and *Cryptosporidium* spp. In the backcountry, inadequate disposal of human waste and pathogens carried by mammals have caused sufficient contamination to make drinking untreated water risky. Low-level release of nutrients from human activities along wilderness lakes may have stimulated increased plant growth on some lake bottoms (Kattelmann 1996) reducing clarity and causing shifts in aquatic communities as well as reducing the aesthetics of natural lake conditions. Very little water from national forests in the Sierra Nevada region is heavily polluted or contaminated.

by chemicals, bacteria, or parasites at concentrations above background levels (Kattelman 1996). Most waters satisfy the fishable and swimmable objectives of the Clean Water Act (1987).

Most pollutants come from non-point sources, that is, originate from diffuse sources not concentrated into pipes, drains, flumes, or ditches (Clean Water Act, 1987). Examples include erosion from roads and parking areas, or drainage from pastures along streams. Sediment at levels above natural rates of erosion is the most common non-point source pollutant in forested ecosystems. A few rural communities and abandoned mining sites within national forests constitute point sources of pollution. The westside of the Sierra Nevada has only 10 municipal and industrial point discharges to streams and rivers (Kattelman 1996).

A significant portion of homes in the Sierra Nevada region rely on individual septic systems since they are too dispersed to connect to sewage treatment systems. Where septic systems are not properly constructed or maintained, sewage containing bacteria may filter into streams. An individual septic system may contribute only a small amount of contamination, but if septic tank problems are common in a residential area, the risk of pollution and disease increases. Similarly, storm water runoff from paved surfaces can contain gasoline compounds, paints, solvents, pesticides, and fertilizers and contaminate streams. The Lake Tahoe Basin Management Unit has taken the lead in cooperating with local and state agencies to manage storm water and other watershed impacts from residential areas.

National forests in the Sierra Nevada occasionally apply chemicals for multiple uses. Herbicides have been applied by a few national forests in areas recently burned by wildfires to kill shrub species competing with young trees on the sites. Pesticides are also used as one of many potential treatments for the control of the invasion and spread of noxious weeds. Most of the time pesticides are applied with hand directed sprayers. Chemicals used include hexazinone, glyphosphate, clopyralid, and triclopyr. Stream monitoring following these applications has shown very little chemical transport into flowing waters (Frazier and Carlson 1991).

Fire suppression teams apply aerial retardant on the flame fronts of wildfires. Formulations for retardant include ammonium phosphate and ammonium sulfate plus various plant-derived binders in a water solution. Retardant compounds are not easily dissolved and therefore, do not move easily into ground water or into surface water from runoff. The nutrient content from nitrogen does provide some benefit to nearby plants where applied, but is overshadowed by the quantity of nutrients released by burning. (Kattelman 1996). Careful planning and implementation are stressed as part of chemical application projects and retardant applications in fire suppression.

In recent years researchers have been concerned about potential effects of atmospheric chemicals in the high-elevation aquatic ecosystems in the Sierra Nevada (Kattelman 1996, Tonnessen 1984, Melack and others 1985). The California Air Resources Board initiated a comprehensive study of the sensitivity of a small alpine lake basin in Sequoia National Park (Tonnessen 1991). This effort explored the hydrochemical processes and biotic responses of this high elevation system to possible shifts in precipitation chemistry. Additional studies of six other lakes have been conducted (Melack and others 1993). These studies indicate that the atmospheric loading rates of hydrogen, sulfate, nitrates, and ammonia are relatively low in comparison to other parts of the country. Snowpack processes can produce a distinct ionic pulse in the early part of the snowmelt season that temporarily lowers pH of these streams and lakes with low buffering capacities. Such surface waters may be at

risk of acidification if air pollution and acidic deposition increase in the future (Cahill and others 1996).

Water Quality Management. The Forest Service in the Pacific Southwest Region has worked with the California water quality agencies to meet Clean Water Act requirements. The greatest emphasis in this coordination has been placed on the management and control of non-point sources of water pollution. Of these non-point sources, sediment, water temperature, and nutrient levels have been the variables of most interest. Best Management Practices (BMPs) have been approved by state water quality management agencies to manage the causes of non-point source pollution. The implementation and effectiveness of the BMPs are reviewed annually. In recent years, the Forest Service has emphasized monitoring on national forest lands to ensure that implemented projects follow approved mitigations and non-point pollution controls. All national forests in California follow the methods and procedures for monitoring of BMPs in the Best Management Practices Evaluation Program (BMPEP).

Clean Water Action Plan. In his 1998 State of the Union Address, President Clinton announced a major new Clean Water Initiative to speed the restoration of the Nation's precious waterways. This new initiative aims to achieve clean water by strengthening public health protections, targeting community-based watershed protection efforts at high priority areas, and providing communities with new resources to control polluted runoff.

On October 18, 1997, the 25th anniversary of the Clean Water Act, Vice President Gore directed the Department of Agriculture (USDA) and the Environmental Protection Agency (EPA) to work with other federal agencies and the public to prepare an aggressive Action Plan to meet the promise of clean, safe water for all Americans. This Action Plan forms the core of President Clinton's Clean Water Initiative. The Action Plan builds on the foundation of existing clean water programs and proposes new actions to strengthen efforts to restore and protect water resources. In implementing this Action Plan, the Federal government will:

- support locally led partnerships that include a broad array of Federal agencies, States, tribes, communities, businesses, and citizens to meet clean water and public health goals;
- increase financial and technical assistance to States, Tribes, local governments, farmers, and others;
- and help States and tribes restore and sustain the health of aquatic systems on a watershed basis.

This Action Plan is built around four key tools to achieve clean water goals.

A Watershed Approach. This Action Plan envisions a new, collaborative effort by Federal, State, tribal, and local governments; the public; and the private sector to restore and sustain the health of watersheds in the Nation. The watershed approach is the key to setting priorities and taking action to clean up rivers, lakes, and coastal waters.

Strong Federal and State Standards. This Action Plan calls for Federal, State, and tribal agencies to revise standards where needed and make existing programs more effective. Effective standards are key to protecting public health, preventing polluted runoff, and ensuring accountability.

Natural Resource Stewardship. Most of the land in the Nation's watersheds is cropland, pasture, rangeland, or forests, and most of the water that ends up in rivers, lakes, and coastal waters falls on

these lands first. Clean water depends on the conservation and stewardship of these natural resources. This Action Plan calls on Federal natural resource and conservation agencies to apply their collective resources and technical expertise to State and local watershed restoration and protection.

Informed Citizens and Officials. Clear, accurate, and timely information is the foundation of a sound and accountable water quality program. Informed citizens and officials make better decisions about their watersheds. This Action Plan calls on Federal agencies to improve the information available to the public, governments, and others about the health of their watersheds and the safety of their beaches, drinking water, and fish.

There are several actions outlined in the CWAP relevant to the SNFPA project. States were mandated to develop a Unified Watershed Assessment to prioritize Federal funding for watershed restoration. That program is discussed in the watershed condition section. Federal agencies were also directed to develop a Unified Federal Policy that was released in February 2000 for watershed management that provides guidance on how agencies will work together and with other non-Federal entities to manage natural resources. The strengthening of Water Quality Standards is being implemented through the Total Maximum Daily Load program described next.

The State of California has listed some water bodies as being “water quality limited” as directed in Section 303 (d) of the Clean Water Act. These reaches of streams, rivers, and lakes repeatedly have water quality conditions that are outside of the limits of the stream water quality standards established to meet the identified beneficial uses for these waters. The State re-evaluates this listing of stream reaches every 2 years. Table I.2.3 (Appendix I, Part 2) lists the locations of these water bodies in the Sierra Nevada region, and the variables of concern. Very few of these waterbodies are listed due to causes related to national forest management. Most causes are related to mining, roads, agriculture, and sometimes grazing. Primary areas of concern are the Lake Tahoe Basin, and the Carson, Walker and Owens Rivers.

The States of California and Nevada will study these watersheds and the listed waterbodies to address point and non-point sources of pollution in another type of cumulative effects analysis referred to as a waste load and load allocation process. The states will use these analyses to set Total Maximum Daily Loads (TMDLs) for pollution sources. Table I.2.3 shows the relative priority for each waterbody study. National forests have been consulting and cooperating with respective Regional Water Quality Pollution Control Boards in the study of these listed reaches of water bodies. The Central Valley and Lahontan Water Quality Control Boards, California and the Nevada Division of Environmental Protection, Bureau of Water Quality Planning have responsibility for the Sierra Nevada region. Activities on private lands have affected many of these waterbodies. The goal of these studies is to bring the variables of concern to levels that are within the stream standards in order to support the identified beneficial water uses.

Aquatic Management Strategy. The Aquatic Management Strategy goals presented in Chapter 2 are neither prescriptions nor standards, but endpoints toward which management will move watershed processes and functions, habitats, attributes and populations. The goals are meant to provide a broad, comprehensive framework for establishing desired future conditions for analysis at the river basin, watershed and landscape scale. Moving ecosystem conditions towards these goals will restore and maintain the physical, chemical and biological integrity of the region’s waters as mandated by the Clean Water Act, and support the Forest Services mission to provide habitat for riparian and, or, aquatic dependent species.

The previous section discussed the factors associated with the first goal, water quality. Part 4 of Chapter 3 and Appendix R discuss the factors associated with goal 2, species viability. Special habitats, goal 4, are discussed later in this section. The following section provides a summary of the relationship of the remaining goals to various factors associated with management activities.

Watershed Connectivity. Connectivity refers to the ease of movement, or rates of exchange, with which water, energy, nutrients, and organisms pass from one area to another, unhindered in the absence of impediments, such as dams, diversions, roads and bridges, large habitat openings, and recreational developments. As ecosystems become fragmented and disconnected, the scale and rate at which essential processes, such as nutrient and energy cycling and gene flow, operate become restricted.

A physical example of connectivity is the exchange of surface flow and groundwater within streambeds and floodplain soils (Boulton and others 1998). Another example is the dynamic interaction of a river with its riparian zone at floodstage when water transports sediments and organic materials from one area and deposits them in another. Chemical connectivity refers to the movement of nutrients from the terrestrial to the aquatic environment, and back. Biological connectivity refers to the continuity of habitats necessary for organisms to successfully complete their life cycles. For example, aquatic insects, fish, and amphibians migrate between different habitats at different stages in their development.

Human activities such as construction of dams, stream diversions, roads and trails, or degradation of streambanks and meadows alter or disrupt watershed connectivity. This disruption often results in different exchange rates within streams and between streams and the terrestrial system. This disruption can negatively affect nutrient availability to organisms, limit the availability of suitable habitat, change the pattern of streamflow resulting in different hydrologic processes and result in the decline of riparian or aquatic dependent species.

Floodplains and Water Tables. Natural relationships between rivers and their springtime floodplains result in exchanges of water and nutrients and sediment movement and deposition (Swanson and others 1998).

Riparian zones undergo annual disturbances to which riparian biotic communities are adapted. These disturbances are distributed in a mosaic pattern that increases habitat diversity and enhances riparian vegetation (Gregory and others 1991).

A major historical influence on water tables and floodplains in meadows has been livestock grazing that reduced the abundance of protective vegetation and also accelerated streambank erosion through trampling. Conditions in many meadows are improving; however, streambeds in many meadows have been lowered relative to the meadow surface as a consequence of channel downcutting.

Functioning meadow systems generally retard flow velocities and retain water on the meadow surface recharging subsurface soil moisture. This stored water is released through the summer maintaining streamflow. The condition of riparian vegetation depends on moisture availability in the water table. If the water table drops or fluctuates greatly, the abundance and type of riparian vegetation may change significantly. An activity that causes a reduction in riparian vegetation, such as overgrazing, may leave stream banks unprotected resulting in accelerated erosion during peak flows. Once erosion has started, stream channels typically downcut, resulting in a lowering of the local water table. The

meadow surface no longer acts as a sponge holding water in storage. Instead the water stored in the meadow quickly drains down to the lowered water table. Water is also released from storage more quickly through the eroded channel banks resulting in reduced summer streamflows. When the water table falls, the site becomes less suitable for riparian vegetation, and drought-tolerant vegetation begins to replace riparian obligate species

Additionally, downcut channels are no longer connected to their historic, wide meadow floodplains but are confined within narrow incised channels. When streams no longer flow on top of meadows, meadow bottomland soils are not replenished with fine silt particles transported by the stream. Also the energy of the stream during high flows is confined to the smaller, incised channel and is not slowed by flowing across the meadow. The result is faster in-channel flow velocities that can result in more streambank erosion. Higher flow velocities also means the water passes through the meadow area more quickly and also that water is resident on the meadow for shorter periods, if at all. This also reduces the amount of water stored in the meadow and streambank, often resulting in the loss of many riparian plant species.

Streambanks and Shorelines. Streamflow Patterns and Sediment Regimes. These two goals are strongly interrelated. The natural stream channel for a reach determines the balance between pool and riffle habitats, natural sediment movement rates, width-to-depth ratios, and channel equilibrium for flow and bedload. Channels that are outside the normal characteristics for an area undergo bank cutting and accelerated erosion. The natural stream channel for an area is a function of its geomorphology, vigor and composition of the riparian vegetation, and soil stability. Highly stable channels are normal for some situations, for example, channels that are deeply incised into bedrock, while highly unstable channels are normal for others such as streams on alluvial plains.

Multiple elements such as substrate composition, streamside vegetation, bank stability, and sediment and water flow regimes characterize favorable aquatic habitat structure and complexity. Other elements include: the ratio of pools to riffles, gradient, water depth and flow, presence and percentage of undercut banks, woody material, and substrate composition

Many fish and aquatic insects prefer habitats with low amounts of fine sediment and high amounts of hiding cover and structural diversity. When normal channel stability is altered, changes in habitat can lead to changes in the composition of stream plant and animal communities. Flow pattern, channel dimension, and channel profile are in equilibrium for stable channels. These features vary as channels adjust to the flow energies applied by flowing water and sediment (Rosgen 1996).

In many aquatic ecosystems, inputs of large woody material from riparian and upslope areas physically and biologically influence aquatic habitats (Harmon and others 1986, Maser and Sedell 1994). Large woody material is important to most stream habitats in forested areas, regardless of stream size (Sedell and others 1984). Large woody material can influence channel morphology by affecting longitudinal profile, pool formation, channel pattern and position, and channel geometry (Bisson and others 1987). Large woody material performs many environmental functions important to fish and aquatic invertebrates. These functions include: forming pool habitats; retaining sediment and gravel; retaining organic matter, particularly from foliage, as food for aquatic invertebrates; providing fish cover; and providing substrates for microorganisms and invertebrates (Swanson and others 1982, Beschta 1983, Bisson and others 1987).

In contrast, a study of woody material in some streams of the central Sierra Nevada, Berg and others (1998) found that woody material played a small role in storing sediment and creating fish habitat. Unlike streams in the Pacific Northwest, large woody material in the study streams was not found to be important for creating pools used by fish. This may not be true for all Sierra Nevada streams, however.

Streams are categorized into three main types based on flow characteristics: perennial, intermittent, and ephemeral. Perennial streams are permanently inundated surface stream courses that are continually connected to the subsurface water system. Surface water flows throughout the year except in extreme drought years when the water table drops below the streambed. Intermittent streams are also hydrologically connected to the subsurface water system but lose the connection as the water table drops, usually in mid-summer. Thus, intermittent streams generally only flow for a portion of the year. Ephemeral streams are not connected to the subsurface water system and flow only in response to intense rainstorms that exceed the infiltrative capacity of the soil or during snowmelt. In this document, intermittent and ephemeral streams together are called seasonally flowing streams.

Riparian vegetation can indicate the type of stream based on flow. Perennial streams usually support riparian obligate plants that require free or unbound water (not held in soil pores under tension) through most of the growing season. Intermittent streams also often support riparian vegetation for most of the growing season. Since ephemeral streams do not have a sustainable source of flow, they are not able to support riparian plant species. In Sierra Nevada national forests, an estimated 54 percent of the streams are ephemeral, 20 percent are intermittent, and 26 percent are perennial (based on U.S. Geological Survey, 7.5 minute quadrangle, topographic maps).

Kattelman (1996) characterized Sierra Nevada landscapes as having relatively low, natural surface erosion rates. Sierra Nevada soils generally have high infiltration rates. Surface erosion is usually minimal because infiltration rates are generally greater than rainfall or snowmelt rates, and water is absorbed into the soil. Approximately 50 percent of the annual precipitation in the Sierra Nevada occurs during the winter, approximately 33 percent in the fall, approximately 2 percent in the summer and the remainder in the spring. Streamflow is the result of snowmelt and seasonal rainfall. Above 8,200 feet, nearly all streamflow comes from snowmelt; below 4,900 feet, nearly all streamflow comes from rainfall (Kattelman 1996). Between 4,900 and 8,200 feet, streamflow comes from a combination of direct runoff from rainfall, runoff delayed somewhat as rain on snow, and runoff delayed longer as snowmelt during warm periods in the winter and spring.

Erosion occurs as a direct result of complex interactions between site topography soils, vegetation, and geology.

Logging operations, grazing, and other activities that disturb the forest floor and compact soil can contribute to the delivery of suspended sediment to stream channels. In many watersheds combined logging and burning activities have increased frequencies of mass soil movements.

Wildfire can accelerate erosion by removing protective vegetation and litter and physically changing the soil surface. Intense wildfires can interact with physical properties of watersheds to change soil properties, vegetation, and hydrology (Beschta 1990), leading to increased erosion and stream sedimentation. In severely burned areas, increased water levels in soils and destruction of vegetation and root systems may increase risk of mass soil movements. Peak flows may increase and accelerate bank erosion, sediment transport downstream, and bed scour, as well as raise or aggrade the

streambed elevation. Catastrophic wildfire may reduce riparian vegetation and eliminate positive effects that riparian buffers have on stream systems. Flowing water on bare soils exposed by wildfire can cause erosive overland flow (sheetflow), rills, or gullies, substantially increasing the sediment load to streams. This accelerated loss of soil negatively affects the soil productivity of the terrestrial system as well as negatively affecting the health of aquatic ecosystems from excessive sedimentation.

Plant and Animal Community Diversity. The condition of aquatic, riparian, and meadow ecosystems directly affects the quantity, quality, and timing of water flows. The quantity and composition of riparian plants influence both the terrestrial and aquatic functioning of riparian areas (Meehan and others 1977, Gregory and others 1991). Riparian vegetation, along with channel and flood plain geomorphology, helps to shape the structure of aquatic habitats. Submerged roots, branches, and large woody debris usually enhance productivity of a stream or river reach by adding habitat complexity and providing cover, particularly for fish.

Vegetation in riparian areas also stabilizes stream banks (Sedell and Beschta 1991); decreases erosion by reducing surface disturbance; prevents downcutting which can lead to lower water tables; and traps and transforms nutrients, chemicals, and sediment by maintaining surface and subsurface hydrologic processes. Riparian vegetation can reduce daily temperature fluctuations in streams. Temperature-moderating effects of riparian vegetation are especially critical for smaller streams. On very large rivers, such as the Sacramento River, the effect of adjacent riparian habitat on overall water temperature is minimal (California State Lands Commission 1993). Riparian vegetation is a major source of organic material for streams. In headwater areas, plant material provides most of the base of the aquatic food chain (Vannote and others 1980). Insects and microorganisms transform coarse leaves and twigs in streams into fine and dissolved organic matter.

Throughout the United States, riparian habitats consistently support greater diversity and abundance of wildlife than most other cover types (Brinson and others 1981). Riparian areas function as habitat for vertebrate wildlife and provide corridors for wildlife movement and migration. They act as wildlife refuges during wildfires and streamsides are often the first areas reoccupied by wildlife after stand replacing fire events.

Researchers have not demonstrated empirical relations between structural characteristics of riparian vegetation and individual wildlife species in the Sierra Nevada. Nonetheless, ecologists believe that dense and diverse riparian vegetation provides a large variety and quantity of nest and perching sites, food from seeds, fruits, and insects and a shady, cool, and moist microclimates. Riparian habitat supports many smaller birds, mammals, reptiles, and amphibians. Chapel and others (1992) noted that sites with naturally occurring riparian vegetation support or conserve associated species.

Moyle and Randall (1996) conducted a comprehensive evaluation of the biotic conditions of watersheds in the Sierra Nevada based on a modified Index of Biotic Integrity. Six basic metrics were used to calculate an index for each of 100 CalWater Hydrologic Subareas. They were presence of: (1) native true (ranid) frogs, (2) native fishes, (3) native fish assemblages, (4) anadromous fishes, (5) trout (distribution of native and non-native species relative to their historic ranges), and (6) stream fish abundance. Seven watersheds received excellent index scores (scores ranged between 80 and 100 percent of the total possible score). A total of 36 watersheds were considered to be in good condition (scores from 60 to 79 percent); 48 watersheds were in fair condition (scores from 40 to 59 percent); and nine were in poor condition (scores less than 40 percent).

Three distinct areas with high biological integrity based on index scores were identified. All three areas have excellent representations of native fish and amphibian fauna, and all occur in natural landscapes relatively free from dams, diversions, and roads.

1. Deer-Mill-Antelope Creek and associated small watersheds in Tehama County, all of which flow through remote, rugged volcanic terrain that is generally unsuitable for dam construction;
2. the North Fork Calaveras and Clavey Rivers in the west-central Sierra Nevada; and
3. the upper Kings River and Kern River watersheds, both of which are at high elevations with steep terrain and low accessibility.

Watersheds having low biological integrity were generally located:

1. at high-elevations where native frogs have suffered significant declines and introduced, non-native trout predominate;
2. at low- to mid-elevations where dams and diversions occur, introduced fish and frogs dominate, or populations of native fish and frogs have declined; and
3. in small, low-elevation watersheds that have been heavily impacted by human activities, such as road building, dam construction, agriculture, mining, and urbanization. Examples of watersheds in this group are the Middle and South Forks of the Yuba, Mono, and Owens Rivers.

Buffers. Stream buffers are the most often used management tool to protect riparian species habitat and water quality values. Stream buffers provide two functions that are often intertwined. Buffers can provide “refuges” from management actions for species but buffers also are the areas that most directly interact with the aquatic and riparian environment. People are most familiar with the concept of stream buffers as a protection zone since that is how they are most often portrayed. However, as discussed above, the upland areas adjacent to the stream are a critical component in the health of the aquatic and riparian ecosystems for a variety of reasons.

Uplands within 300 feet of water are often used by riparian associated species such as birds, because of their nearness to water. Some amphibians and reptiles move from the riparian zone into upland areas to overwinter, feed, and migrate to other riparian areas. Western pond turtles spend a significant amount of time from late September through late June under cover in upland habitats. They have been found as far as 1,300 feet away from water (Reese, 1996). Mountain yellow legged frogs have been found up to 200 feet away from water for overwintering (Pope, 1999). California red legged frogs move upland during the rainy season and have been found more than 2 miles from a water source during migration (US Fish and Wildlife Service, 2000). Many authors have found that unmanaged buffers adjacent to streams at least 200 feet wide and often up to 350 feet wide seem to mimic undisturbed forest stands and are used extensively by several bird species. When the strips were narrower, fewer birds were found (Darveau and others 1995, Dickson and others 1995, Hagar 1999, Kinley and Newhouse 1997).

Upland areas also provide input to the riparian zone. Nutrients from decomposing vegetation are transported through the buffers by subsurface and surface flow to the stream. The upland forest moderates not only stream temperature but also air temperature within the riparian zone. A study in eight stream basins in the Sierra Nevada found that microclimates within riparian zones were affected by changes in vegetation up to 600 feet away from the stream (Erman and Erman 2000).

Riparian areas have also been identified by many researchers as critical areas for minimizing sediment input into streams. McGurk and Fong (1995) summarized the work of several studies that consistently found that effects of logging activities within 300 feet of streams significantly affected the aquatic invertebrate community. Aquatic invertebrates are commonly used to assess the health of stream systems since they can be classified into species that are tolerant of high sediment conditions and those that are not tolerant of sediment. The studies often found that logging associated activities within 300 feet of streams, even with a small buffer in place adjacent to the stream, had the same negative effect on riparian communities as having no buffer. The studies also found that logging associated activities more than 300 feet from the stream did not have any significant impact on the aquatic invertebrate community.

Erman and others in a paper in the SNEP report (1996) proposed that the stream adjacent area could be divided into two zones: the community area and the energy area. The community area is the critical habitat required by riparian dependent species. They suggest that the focus within this area should be the maintenance or restoration of conditions required for these species. The size of the zone would vary dependent on the species present and thus would need to be set at a site-specific level. One concern is that the habitat requirements and life connections of the species are often not well known. They suggest that research needs to be conducted to determine these factors.

The energy area would be an area upslope of the community area that provides for exchange of nutrients between uplands and riparian areas and provides microclimate control for riparian areas. This zone could vary in width not only along a stream but also seasonally depending on the vegetation type. The Forest Ecosystem Management Team (FEMAT, 1993) suggested that tree heights be used as a measure to determine the width of a zone analogous to the energy area proposed by Erman. Areas within one tree height obviously have direct interaction with the riparian area since trees can fall from the upslope into the riparian area. The FEMAT team proposed making the zone at least two tree heights wide (generally 300 to 350 feet) to provide for microclimate effects, buffer against sediment input, and provide additional area for nutrient exchange. As noted above, Erman and others found in a recent study that the microclimate effects may extend as far as 600 feet from the stream's edge.

Watershed Condition. There is a close connection between aquatic and riparian ecosystem conditions and the condition of the upland watersheds in which they are located. Effects of land management activities move downslope and downstream, merging below each stream confluence in an additive manner. Impacts may result from vegetation removed during timber harvesting, road building, grazing, mining, reservoir construction, and wildfire. The level to which watershed conditions are affected relates to the aerial extent and intensity of impacts. The "natural sensitivity" of a watershed strongly influences the potential for watershed condition changes as well. Factors influencing natural sensitivity include soils, geology, average watershed, channel type, climate, precipitation regime, watershed shape, drainage density, vegetation type, and past history of natural disturbances.

Management activities in past decades have had varying levels of effects on the condition of the upland watersheds as well as the aquatic and riparian ecosystems. Grazing, road building, recreational development, timber harvesting and mining are the major management related effectors of watershed condition.

Timber harvest often requires the use of heavy equipment that can result in compacted soils. Soil compaction results from repeated passes of equipment over the same piece of ground, such as tractors moving logs over skidroads to landings. This compaction problem is compounded as stand management moves toward multiple entries over relatively short time spans to perform partial cutting or mechanical treatment of fuels. In subsequent entries, the area that was disturbed in the first entry is re-disturbed before natural restoration processes occur. In some cases, ground disturbed but not compacted in the first entry may be more susceptible to compaction in the second entry. As soils are compacted, infiltration is reduced; runoff from precipitation events tends to move over the compacted soil surface dislodging soil particles, and accelerating erosion. A network of compacted skidroads can act as defacto stream channels, focusing flow and initiating gullies. These gullies often enter natural drainage networks, increasing runoff, and delivering high sediment loads to the receiving natural drainages.

Historically, mining, especially hydraulic mining caused massive sedimentation. From the 1850s until the 1880s when hydraulic mining was terminated by legislation, 1.5 billion cubic yards or 930,000 acre feet of mining debris entered Sierra Nevada rivers, 87 percent of it into the Feather, Yuba, Bear, and American rivers alone (Larson 1996). This amount nearly equals the volume of Folsom Reservoir. These rivers received sediment deposits tens of meters deep, and the Yuba River experienced sedimentation up to 25 times that of natural levels (Kattelman 1996). The effect of mining on Sierra Nevada streams is probably second only to dams in creating profound changes in the aquatic environment. As with dams, the long term effects of historic mining are often greater than the current effect of management activities.

Current mining activities for locatable minerals are governed under regulations that implement the 1872 Mining Act. Surface occupancy of existing active mining claims is administered according to the terms of an operation plan that has been approved by the Forest Service. Operation plans provide for surface resource protection, which includes directions developed under the National Forest Management Act and other laws including the Clean Water Act and the Resource Conservation and Recovery Act. Areas of special resource values that are incompatible with future mining activity may be proposed for withdrawal from future claims for a period of time, commonly 20 years, at which time the special resource value is re-evaluated. This may apply to critical habitat for a listed species under the Endangered Species Act or sensitive species listed by the State or Forest Service.

Suction dredge mining permits may be obtained for streams on national forests. Suction dredges suck materials from streambeds so that rocks and gravel can be sorted from gold deposits. The spoils are redeposited in the stream. Fine sediments are suspended but re-settle quickly. Dredging is restricted along stream banks and access to mining sites is carefully located. Seasonal limitations are often made to prevent water quality impacts that would affect trout and salmon spawning and egg incubation. The alternatives in this FEIS would not affect mining operations unless the claim became inactive and a new operation plan was needed.

Roads modify natural mountainside drainage networks and accelerate erosion processes. These changes can alter physical processes in streams, leading to changes in streamflow regime; sediment transport and storage; channel, streambank, and streambed configurations; substrate composition; and slope stability next to streams (Furniss and others 1991).

The greatest risk of sediment moving into streams occurs where roads cross streams. In recent decades, road engineering and construction practices have improved to alleviate this problem. National forest lands within the Sierra Nevada contain approximately 25,000 miles of roads with an average road density of 2.2 miles per square mile. Road building has decreased in the 1990s, while road decommissioning and obliteration have increased (Kattelman 1996). Existing roads constitute current and potential sources of sediment. In general, higher road densities translate to higher potential for adverse effects to aquatic and riparian habitats.

Roads are considered the principal cause of accelerated erosion in forests throughout the western United States (California Division of Soil Conservation 1971, California Division of Forestry 1972, Reid and Dunne 1984, McCashion and Rice 1983, Furniss and others 1991, Harr and Nichols 1993). The locations of roads determine the degree of potential impacts, making some roads more environmentally sensitive than others. The presence of roads can increase the frequency of slope failures compared with the rate for undisturbed forest by hundreds of times (Sidle and others 1985). Road stream crossings constructed with culverts have been identified as a significant source of road derived sediment (Hagans and Weaver 1987, Best and others 1995, Weaver and others 1995, Park and others 1998). In addition, vegetation removal activities conducted within 300 feet of streams have been found to significantly negatively influence stream channel conditions (McGurk and Fong 1995).

Watershed Condition Assessment Programs. Several formal studies have been recently completed that assess watershed condition. These include several programs implemented as part of the Clean Water Action Program. At the Federal level, the Unified Watershed Assessment (UWA) was completed in 1998 to identify large sub-basins in need of restoration. State water quality agencies together with the US EPA have also designated water quality limited bodies and initiated the TMDL program as discussed above in the water quality section. The Forest Service recently conducted a Watershed Condition Assessment (WCA) nationwide to assess the physical and biological health of national forest watersheds.

The following sections report the results of the UWA and WCA assessments as well as results from two analyses designed specifically to address watershed condition, cumulative watershed effects and trends in SNFPA watersheds. Appendix I contains vicinity maps that identify the various hydrologic provinces, river basins, and watersheds discussed below.

Unified Watershed Assessment. The Clean Water Action Plan released on February 19, 1998, requested that States and tribes, with assistance from Federal agencies and input from stakeholders and the public, convene a collaborative process to develop a Unified Watershed Assessment (UWA) to guide allocation of new Federal resources for watershed protection. In California and Nevada, the committees decided to use the 4th field sub-basins delineated by the U.S. Geologic Survey, which are equivalent to the river basins in Appendix I as the watershed area to be evaluated.

The Plan called for watersheds to be placed into one of four categories:

- Category I - Watersheds that are candidates for increased restoration activities due to impaired water quality or other impaired natural resource goals (emphasis on aquatic systems).
- Category II - Watersheds with good water quality that, through regular program activities, can be sustained and improved.
- Category III - Watersheds with pristine or sensitive areas on Federal, State or tribal lands that need protection.
- Category IV - Watersheds where more information is needed in order to categorize them.

In California, the following criteria were used to determine impairment for placement in Category I:

- water bodies listed as having important beneficial uses (for example, drinking water, recreation, fisheries, agriculture and wildlife)
- watershed is identified by local groups as needing improvements for water quality and other natural resource goals
- watersheds under threat of severe wildfires and attendant severe erosion due to very high fuels loading
- aquatic and wetlands species proposed or listed under State or Federal endangered species laws are present
- impaired quality of aquatic and riparian systems as identified by the professional judgment assessment (PJA)
- streams and, or, riparian areas identified as not functioning or functioning at risk using the Proper Functioning Condition (PFC) Assessment method developed by Forest Service, Bureau of Land Management (BLM) and Natural Resource Conservation Service

Watersheds were considered to be Category III, if they were not impaired (in essence not Category I), and more than 25 percent of the watershed consisted of:

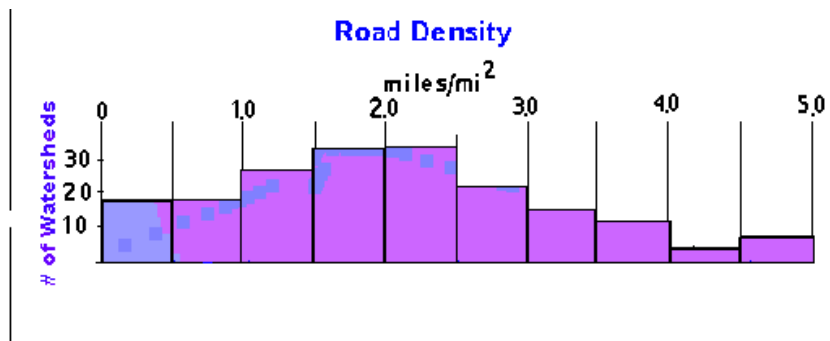
- designated wilderness areas,
- National Park Service lands,
- BLM areas of critical environmental concern,
- national recreation areas,
- State parks and reserves,
- Federal and State wild and scenic rivers

The remaining watersheds were classified as Category II. No watersheds in California and none within the SNFPA project area in Nevada were placed in Category IV, insufficient information to classify. Table 3.4b lists the river basins within the SNFPA area that were classified as Category I. More information on the UWA is available through the Natural Resource Conservation Service website (<http://www.ca.nrcs.gov.wps/>) or the Nevada Division of Environmental Protection website (<http://www.state.nv.us/ndep/bwqp/>).

Figure 3.4b. List of Category I Watersheds from the Unified Watershed Assessment.

Hydrologic Province	River Basin	HUC 4 #
Upper Sacramento	Upper Pit	18020003
	Mill-Big Chico	18020119
Lower Sacramento	Upper Yuba	18020125
	Upper Bear	18020126
	North Fork American	18020128
San Joaquin River	Upper San Joaquin	18040006
	Upper Cosumnes	18040013
Northern Lahontan	Honey-Eagle Lakes	18080003
Central Lahontan	Lake Tahoe	16050101
	Truckee River	16050102
	Upper Carson River	16050201
	Eagle Valley (Middle Carson)	16050202
	Upper East Walker (East Walker)	16050301
	Walker River (West Walker)	16050302
	East Walker River (Walker)	16050303
	Whiskey Flat (Walker Lake)	16050304
Southern Lahontan	Mono Lake	18090101
	Crowley Lake	18090102
	Owens Lake	18090103
	Eureka Saline Valleys	18090201

WCA Program. The Watershed Condition Assessment (WCA) has recently been completed by the Forest Service in California (USDA Forest Service 2000) as one of the action items for the Clean Water Action Plan. This assessment used several road-stream interaction factors including: road stream crossings, roads within 300 feet of streams, roads on the lower third of slopes, and the presence of roads on steep slopes as well as on soils and geologic parent materials that have the highest potential for erosion or mass wasting (de la Fuente and others 2000). The findings of this study that apply to the SNFPA area are displayed below. The data used for this analysis is displayed in Table I.2.1 in Appendix I.

Figure 3.4a. Distribution of Road Density by Watershed.

Road densities within the SNFPA area ranged from 0.0 to 5.1 miles per square mile. Table 3.4c lists the watersheds within the SNFPA area that have the highest 5 percent of road densities.

Table 3.4c. Highest Road Densities.

WATERSHED NAME	Density (mi/sq mi)	Hydrologic Province
Tahoe North Shore	5.23	Central Lahontan
Lower SF Tuolumne	4.85	San Joaquin
Upper NF Cosumnes River	4.67	San Joaquin
Upper MF Mokelumne	4.62	San Joaquin
Rock (includes Slab Creek)	4.61	Lower Sacramento
Middle NF American River	4.59	Lower Sacramento
Burney Creek	4.32	Upper Sacramento_

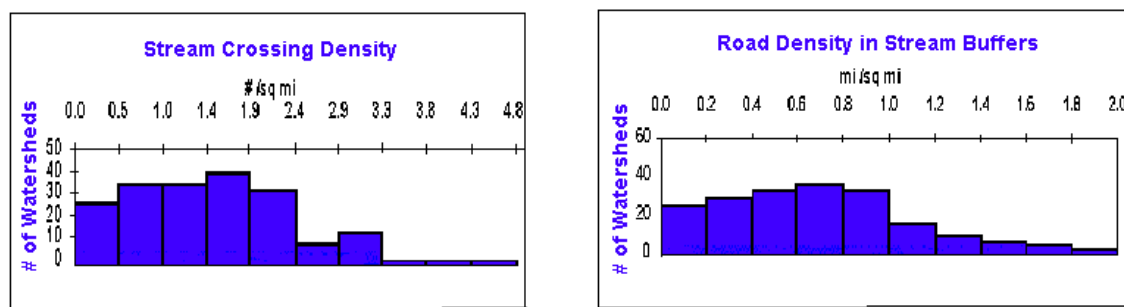
The results of the four additional road/stream factors assessed were:

- stream crossing densities: ranges from 0.0 to 4.8 crossings per square mile,
- road densities within 300 feet of streams: ranges from 0.0 to 2.0 miles per square mile,
- road densities on lower third slopes: ranges from 0.0 to 2.9 miles per square mile, and
- road densities on steep (greater than 45percent) slopes: ranges from 0.0 to 0.7 miles per square mile.

Table 3.4d lists the watersheds within the SNFPA area that have the highest densities for four factors: road density, roads in lower third of slope, roads within 300 feet of the stream, and roads located on steep slopes. If a watershed is in top 5 percent for any factor and also had road densities within top ten percent the density is also displayed. Highlighted rows indicate watersheds that rank in the top grouping for all stream factors. Figure 3.4b below shows the distribution by number of watersheds of the density of road/stream crossings and the density of roads within stream buffers.

Table 3.4d. Watersheds with the highest road density for all factors.

Hydrologic Province	Watershed Name	Road Density	SN Rank	Lower 3 rd of Slope	SN Rank	Within 300 feet of stream	SN Rank	Steep slopes	SN Rank
Central Lahontan	Tahoe North Shore	5.23	1	2.94	1	*	*	*	*
	Tahoe East Shore	*	*	2.00	4	*	*	*	*
	Middle Truckee River	*	*	1.85	9	*	*	*	*
Upper Sacramento	Burney Creek	4.32	9	2.13	2	*	*	*	*
	Bear Creek	*	*	2.03	3	*	*	*	*
Lower Sacramento	American-Alder	4.05	11	1.65	16	1.49	6	*	*
	Butt Valley	*	*	1.87	8	*	*	*	*
	East Branch NF Feather River	*	*	*	*	*	*	0.28	7
	Fall River-South Branch	3.91	13	*	*	1.42	9		
	Middle NF American River	4.59	6	1.69	14	1.64	3	0.24	10
	Rock	4.61	4			1.51	4		
	Seneca-Belden	*	*	*	*	*	*	0.42	3
	Slab	4.58	8	*	*	1.4	9	0.31	5
	Volcano Canyon-Otter Creek	*	*	*	*	*	*	0.34	4
	Blue-Tiger	3.88	14	*	*	1.27	13	0.24	9
	Camp Creek	4.15	10	*	*	1.43	7	*	*
	Lower MF Toulumne	4.59	7	1.88	5	1.23	18	*	*
San Joaquin	Lower SF Tuolumne	5.05	2	1.80	10	1.58	5	0.70	1
	North Fork Tuolumne	3.79	16	*	*	1.27	14	0.30	6
	Upper MF Mokelumne	4.62	5	1.85	8	1.75	2	0.21	14
	Upper NF Cosumnes River	4.67	3	1.87	6	2.00	1	*	*
	Upper SF Mokelumne	*	*	*	*	1.37	11	0.49	2
Tulare Buena Vista Lakes	Tenmile-Indian Basin	*	*	*	*	*	*	0.26	8

Figure 3.4b. Distribution of Stream Crossing Density and Road Density within 300 feet of Stream.

Since road stream crossings have been documented as having the potential to contribute the most predictable sediment loads they are listed in Table 3.4e to highlight the watersheds having the highest number of crossings per square mile.

Table 3.4e. Watersheds with highest density of stream crossings.

Hydrologic Province	Watershed Name	Stream crossing Density (# / sq mi)
Lower Sacramento	Wolf Creek	4.75
Lower Sacramento	Middle NF American River	4.73
Lower Sacramento	Seneca-Belden	4.08
San Joaquin	Upper MF Mokelumne	3.60
Lower Sacramento	American-Alder	3.53
Lower Sacramento	Butt Valley	3.34
North Lahontan	Upper Dismal Creek	3.25
Lower Sacramento	Yellow Creek	3.21
Central Lahontan	Tahoe North Shore	3.19

Cumulative Effects and Trends Analysis. Years of grazing, mining, road building, home construction and logging disturbances as well as fire, landslides and plant disease has modified forest ecosystems. Present remote sensing technology provides a means for understanding, monitoring and in some cases quantifying these natural and management changes such as soil loss, changes in vegetative cover, and the consequences of habitat disturbance at a landscape scale. Comparison of current condition on a watershed by watershed basis allows us to index ecosystems relative to each other. An accurate indexing methodology is a valuable tool when allocating resources for Cumulative Watershed Effects (CWE) mitigation or adjudicating disturbance rights among landowners in mixed ownership watersheds.

The methodology presented here assesses the ecosystem for “natural sensitivity” based on physical parameters and on “levels of activity” based on both physical parameters and historical management records. The parameters used in the level of activity analysis represent the primary “effectors” of the aquatic and riparian ecosystems. This methodology looks beyond national forest boundaries and considers all lands and activities within a River Basin. This model includes several GIS layers that, when analyzed together, provide a more objective view of ecosystem condition.

Parameters used to determine “natural sensitivity” levels include:

- Natural Resources Conservation Service (NRCS) data on soil detachability and hydrologic group function,
- U.S. Geologic Survey’s 2-hour rainfall intensity coverage for areas with rainfall intensity greater than 0.80 inches in two hours,
- California’s State Division of Mines and Geology statewide geologic coverage focusing on both geologic formations and formation contact zones (Six hundred foot wide buffers were placed around the contact zones between flow and ejected volcanics. A 1,200 foot wide buffer was established for the contact zone between metasedimentary and granitic formations. The volcanic contact zone contains springs that are primary contributors to mass failure while the granitic contact zone is prone to both gully erosion and mass failure. The formations chosen were the same as those agreed upon by the Forest Service hydrologists and geologists for use in the Regional Watershed Condition Analysis model discussed above).
- slope grids for slopes greater than 45 percent and greater than 65 percent created from data prepared for the SNEP analysis (Slopes greater than 45 percent represent the break point where cover for bare soil becomes critical and where any disturbance substantially increases the potential for erosion. Slopes greater than 65 percent represent inner gorge conditions where unstable soils and geology often lead to mass failure when disturbed).
- areas where stream gradient is less than 3 percent (These areas were included because of their potential to aggrade sediments, resulting in diminished habitat availability for many aquatic dependent species).
- the elevation band where rain-on-snow predominates, assumed to be 4,000 to 6,000 feet,
- areas where the mean annual precipitation is greater than 55 inches (from CA DWR data base),
- stream density and drainage pattern as an indicator of geologic stability,

Level of activity factors or “landscape effectors” used in the model include:

- the fire history coverage developed by the Forest Service Fire Sciences Group and the California Department of Forestry and Fire Protection (From this data, a map layer for the decades from the 1950s, through the 1980s was created in order to count repetitive fires at the same location).
- the Forest Service State and Private Forestry Group's change detection analysis from satellite data for the 1991 to 1996 period (Slight to heavy increases and decreases in greenness were used to infer disturbance from all natural and anthropogenic occurrences. It was assumed that increases in greenness are linked to past disturbance that is currently healing. Decreases in greenness were assumed to represent recent removal of vegetation resulting in areas more at risk for accelerated erosion. Thus decreases in greenness were given more weight than increases).
- the sediment correlations for road/sediment delivery developed by the Pacific Southwest Region Watershed Analysis team (These were used to classify potential sediment delivery by the road system. The road grid was classified into roads contributing 0.005 to 1.76 tons of sediment per surface acre of road per year and roads contributing 1.77 tons to 2.8 tons of sediment per acre per year).
- the intersection of roads and streams,
- the U.S. Geological Survey coverage of abandoned mine data (These points were buffered by 1,000 feet based on the amount of disturbance surrounding abandoned mines measured by both State and Federal Abandon Mine Survey teams).

- recreation disturbance including both public and private recreation facilities and heavily used areas (These points were buffered by 300 feet).
- grazing impacts including all areas within active grazing allotments (Allotment areas within perennial and intermittent riparian zones were weighted more heavily).

The GIS moving grid analysis was conducted separately for the sensitivity factors and the activity level factors at both the river basin and watershed scale. Results were grouped into three general categories of low, moderate, and high. Thus nine combinations of sensitivity and activity levels were generated.

Interpretation of the nine combinations of sensitivity and activity levels can be used to assist in determining broad scale watershed conditions. A high activity level may reflect an area with a history of catastrophic wildfires or an area with high historic levels of timber harvest or grazing. Areas that score high in both natural sensitivity and activity levels may represent areas that have exceeded their tolerance for disturbance and are in need of restoration. Watersheds that rank high in “activity level” should be assessed to determine whether current management activities need to be changed or if restoration is needed. Possible watershed condition scenarios linked to the nine combinations are shown in Table 3.4f.

Table 3.4f. Sensitivity/Activity Interpretations.

Sensitivity/Activity	Disturbance tolerance	Management Action
High /High	Tolerance exceeded	Review existing activities/Restoration is a priority
High/Moderate High /Moderate	At or above tolerance At or above tolerance	Review existing/Caution for new activities/Restoration caution for new activities/ restoration
High/Low	Below tolerance	Review existing/Caution for new activities/Maintenance
Moderate/High	At or above tolerance	Review existing/Caution for new activities/Restoration
Moderate/Moderate	At or below tolerance	Review existing/new activities possible/Restoration
Moderate /Low	Below tolerance	New activities possible/Maintenance
Low/High Low/High	At or above tolerance At or above tolerance	Review existing/Caution for new activities/Restoration
Low /Moderate	Below tolerance	Review existing/ new activities possible/Maintenance
Low /Low	Well below tolerance	Many options to increase activity level

Table 3.4g summarizes the results of this analysis for river basins and Table 3.4h summarizes the results for watersheds. The data by river basin and watershed is displayed in Table I.2.1 in Appendix I. At the river basin level, about 50 percent of the SNFPA landscape was rated as having low natural sensitivity, 30 percent rated moderate and 20 percent rated high. In terms of activity levels, about 35 percent have low activity levels, 50 percent have moderate activity levels, and 15 percent have high activity levels.

Six river basins had high activity levels. The river basins rated as moderately sensitive with high activity levels are the East Branch North Fork Feather River, Upper San Joaquin River, and Upper Tuolumne River. Those rated as highly sensitive with high activity levels were the South Fork American River, Upper Kings River, and Upper Stanislaus River. These six watersheds all have experienced large catastrophic wildfires in the past two decades and have been actively managed for timber and grazing.

Table 3.4g. Rating of Natural Sensitivity and Activity Level by River Basins.

		Natural Sensitivity		
		LOW	MOD	HIGH
Activity Level:	LOW	19	4	5
	MOD	7	5	4
	HIGH	0	3	3

The watershed scale provides more specificity as to which watersheds within the river basin have the highest level of sensitivity as well have the highest activity level. At the watershed scale, the classification of sensitivity level changes slightly from the larger river basin scale. About 20 percent of the landscape rates as most sensitive which is the same as the river basin level, but slightly less land (25 percent) rates as moderately sensitive and slightly more (55 percent) rates as least sensitive.

Table 3.4h. Rating of Natural Sensitivity and Activity Level by Watershed.

		Natural Sensitivity		
		LOW	MOD	HIGH
Activity Level:	LOW	86	29	27
	MOD	29	30	9
	HIGH	8	8	21

At the watershed scale, 37 watersheds rated as having high activity levels; 21 watersheds had both high natural sensitivity and high activity levels. Many of these watersheds are located within the six high activity level river basins, but several are in other areas, as shown below in Table 3.4.i. Completing the analysis at this finer scale helps to identify more specific areas that may be in need of restoration, require changes in management, or provide opportunities for an increased level of activity.

Figure 3.4i. Watersheds that rated high in activity level.

Sensitivity/ Activity	River Basin*	Watershed
HH	North Fork Feather River	Yellow Creek
HH	Middle Fork Feather River	South Fork Feather River
HH	Upper Yuba River	Lower North Yuba
HH	Upper Yuba River	Middle Yuba
HH	North Fork American River	North Fork Middle Fork American River
HH	South Fork American River	American-Alder
HH	South Fork American River	Silver Creek
HH	South Fork American River	Rock Creek
HH	Upper Kings River	Mill Flat Creek
HH	Upper Kings River	Dinkey Creek
HH	Upper Kings River	Pine Flat Creek
HH	Upper San Joaquin River	Mammoth Pool Reservoir
HH	Upper San Joaquin River	Chiquito Creek
HH	Upper San Joaquin River	Shaver-Redinger
HH	Upper San Joaquin River	Willow Creek
HH	Upper Merced River	Ned-Bear
HH	Upper Merced River	North Fork Merced River
HH	Upper Tuolumne River	Clavey River
HH	Upper Tuolumne River	North Fork Tuolumne River
HH	Upper Stanislaus River	South Fork Stanislaus River
HH	Upper Stanislaus River	Lower Middle Fork Stanislaus River
MH	Lost River-Lower Klamath River	Bole-Fletcher
MH	Lost River-Lower Klamath River	Copic Bay
MH	Lower Pit River	Egg Lake
MH	Upper Kern River	Rattlesnake-Sacratone
MH	Upper San Joaquin River	Big Creek
MH	Upper San Joaquin River	Shaver-Millerton
MH	Upper Tuolumne River	Jawbone
MH	Upper Tuolumne River	Middle Tuolumne River
LH	Truckee River	Middle Truckee River
LH	Truckee River	Little Truckee River
LH	Lower Pit River	Butte Creek-Lost Creek
LH	East Branch North Fork Feather River	Upper Indian Creek
LH	East Branch North Fork Feather River	Last Chance Creek
LH	Upper Kern River	Salmon-Bull Run
LH	South Fork Kern River	Upper South Fork Kern River
LH	Honey-Eagle Lakes	Upper Susan River

*Highlighted rows are watersheds located in River Basins also ranked high in activity level.

Trend Analysis. With the advent of GIS technology, spatial analysis procedures are available to quantify both present and historic physical features and land use practices on a landscape basis. From the rates of change in these features, as determined by GIS interpretations of aerial and space imagery, habitat improvement or degradation and habitat potential may be inferred. This “change detection” analysis can be used to determine the pattern of vegetative changes across the landscape. This pattern can help identify areas impacted by urbanization, areas affected by catastrophic wildfire, or areas with intensive vegetation management. Since the change is analyzed in five year increments (from 1986 to 1991 and 1991 to 1996), and is based on a detectable change in light reflectance from the vegetation, it does not pick up subtle changes such as limited thinning of forests. If a change is detected, it generally means that an area has either lost or gained vegetation over the five year period.

Slight to heavy increases and decreases in “greenness” were used to infer disturbance from all natural and anthropogenic occurrences. It was assumed that increases in “greenness” are linked to a past disturbance that is currently healing. Decreases in “greenness” are assumed to represent recent removal of vegetation resulting in areas more at risk for accelerated erosion. Very high increases or decreases in “greenness”, especially in the eastern Sierra Nevada and western foothill river basins

may represent an artifact due to variations in climate. The sets of photos compared were taken in July for each time period, but differences in rainy seasons between the years the sets of photos were taken could influence interpretations, particularly in these two areas.

The change analysis results were overlain on administrative layers composed of three ownership classes: national forest lands, other State or Federal lands, and private lands. The results are displayed in Table I.2.2 in Appendix I and summarized in Table 3.4j. In general, the total percentage of a watershed undergoing some type of change in greenness is less than 10 percent. Of those that had a greater than 10 percent change, several are small river basins where a small change in total acres can result in a large percentage change.

Three interesting trends were observed in reviewing the results. First, the total amount of acres that “changed” regardless of increase or decrease in greenness was greater in all but four river basins for the 1991 to 1996 time period than compared to the 1985 to 1991 time period, implying more “activity” took place in the later analysis. Secondly, the number of river basins with more than 10 percent total change in greenness increased substantially in the 1991 to 1996 analysis when compared to the 1985 to 1991 analysis. Third, the number of basins where decrease in greenness was greater than increase was reversed between the 1985 to 1991 analysis and the 1991 to 1996.

A review of the data suggests that the period 1985 to 1991 was characterized primarily by decreases in vegetation while the period 1991 to 1996 reflects the regrowth of those areas since greenness increased. The one anomaly was the Upper Calaveras where the decrease in greenness stayed high for both time spans. A review of activities in the watersheds listed in Table 3.4k show that there were many large, catastrophic wildfires during the time span 1985 to 1991. There also was a change in forest management in the early 1990s when clear-cutting became less prevalent and thinning more common.

Table 3.4j. Relative changes in greenness.

Change in Greenness	85-91	91-96
Increase > Decrease	14	13
Decrease > Increase	32	33
Increase = Decrease	3	3
Decreases > 35% of total change	36	19
Decreases > 50% of total change	13	12
Decrease > 75% of total change	17	1
Increases > 35% of total change	26	39
Increases > 50% of total change	15	33
Increase > 75% of total change	8	22

Table 3.4k. River Basins with more than 10% total change.

85-91	91-96	Comments
Upper Yuba		wildfires in 85-91, decr in 85-91, incr in 91-95
Upper Bear		decr in 85-91, incr in 91-95
	Mill-Big Chico	Small WS, decr in 85-91, incr in 91-95
	Upper Butte	Small WS, decr in 85-91, incr in 91-95
	East Branch North Fork Feather	decr in 85-91, incr in 91-95
	Middle Feather	decr in 85-91, incr in 91-95
	Upper Chowchilla	Increase stays high, climate related?
	Upper Merced	wildfires in 85-91 decr in 85-91, inc in 91-95
	Upper Stanislaus	wildfires in 85-91
	Upper Calaveras	Decrease stays high
	Mill (San Joaquin)	Small WS, incr stays high, climate related?
	Upper Dry	Small WS, incr stays high, climate related?
	Upper King	Decrease in 85-91, increase in 91-95
	Walker	High Decrease in 91-96
	Eureka-Saline Valleys	Increase stays high, climate related?

Meadows, Wetland, and Other Special Aquatic Features

Descriptions and definitions

Riparian-wetland ecosystems vary as a result of many factors; therefore, they are grouped into two major categories: (1) lentic, which is standing water habitat or by the standing water of lakes, ponds, seeps, bogs and meadows, and (2) lotic, which is running water habitat such as rivers, streams, springs. These ecosystems are characterized by the interaction of three physical components: (1) vegetation, (2) landform and soils, and (3) hydrology (USDI-BLM 1993, 1994).

Lentic riparian-wetlands have characteristic soil deposition patterns that resulting in water ponding, slow drainage and other hydric properties. Soils properties range from aerobic (well oxygenated) to anaerobic (low oxygen availability) and vary widely in pH levels. Oxygen level and pH have strong effects on plant alliances resulting in unique assemblages and endemic species. Generally, lentic riparian-wetlands favor herbaceous vegetation. Depending on geography and local factors, various combinations of grass, sedge, rush, spikerush, bulrushes, forbs and mosses can dominate the site. In contrast lotic riparian-wetlands have soil deposition patterns that produce accumulations of coarser materials resulting in well drained soils with aerobic properties and alluvial features such as stream point bars, imbedded woody debris, rock and cobble substrates. Lotic riparian-wetlands often contain a mixture of herbaceous and woody or shrubby plant species. Streamside riparian flora often contain intermixes of sedge and willow-dominant plant alliances along a single stream reach or meadow channel. To a great extent, the geomorphology of the stream system determines whether herbaceous or shrubby plant communities dominate the system.

Species compositions are extremely diverse even within individual meadows and certainly across meadows in the Sierra Nevada Bioregion (Ratliff, 1985). Large meadow complexes often contain lentic and lotic processes as well as special aquatic features such as seeps, fens or springs. Ratliff (1985) suggested that based on species, topography, and hydrology over 1,500 meadow types can be identified in the Sierra Nevada Bioregion. He presented 12 broad meadow subformations that are based on physical features of Sierra Nevada meadows such as margin type (vegetated or sandy) and topographic position (basin, slope or stream; and montane or subalpine). Ratliff identified six hydrologic classes for meadows in the Sierra Nevada that are inclusive of sites having special aquatic features. The hydrologic classes presented were:

1. raised-convex - a site with an enclosed open water surface occurring as a mound above the surrounding meadow;
2. hanging - a site that occurs on a slope and is constantly watered by flow from springs and seeps;
3. normal - a site that obtains water from the water table, is recharged by precipitation, and may dry in the surface during summer;
4. lotic - a site that is characterized by moving water and constantly watered by flows from upstream;
5. xeric - a site that occurs on a slope or bench, is seasonally recharged by precipitation, and becomes quite dry during summer; and
6. sunken-concave - a site that is characterized by ponded water, seasonally recharged by flows from upstream.

Resource managers generally group Sierra Nevada meadows on three sets of characteristics: (1) wet, moist, or dry; (2) woody or shrubby, or herbaceous; and (3) montane or subalpine elevation zone. Further distinctions are made within wet meadow complexes where special aquatic features exist such as minerotrophic peatlands (fens). Ecological type descriptions and scorecards have been developed for these general meadow classifications using grouped plant associations as indicators of high, mid or low similarity to potential natural communities.

Wet and moist meadows typify those found on the west slope of the Sierra Nevada in the montane zone. Dry meadows are more commonly found in the eastern Sierra Nevada and southern High Sierra Nevada (Weixelman and Fites 1999). A continuous vegetation canopy and standing water during all or part of the year characterizes wet and moist meadows. These meadows grade from sites with standing water, dominated by mosses (like sphagnum) and rushes (*Juncus* spp.), to more well drained sites dominated by sedges, grasses, and forbs. Dry meadows generally contain no standing water and are composed of dryland sedges, grasses and forbs. Subalpine, meadows dominated by Short hair sedge (*Carex filifolia*) are examples of high elevation dry meadows. Willows may be a component of meadow vegetation along stream courses within the meadow (Shiflet 1994).

Biodiversity in meadow ecosystems

Many animal species, particularly birds and amphibians use, or are dependent upon meadow ecosystems. Many more use the ecotones between meadows and the forest edges. Of the focal animal species listed in the Notice of Intent, willow flycatcher (Parts 4.3.3) Yosemite toad and the northern leopard frog (Parts 4.3.5) are dependent upon meadows. Appendix R identifies nineteen other species of high vulnerability including Swainson's thrush, long-eared owl and western red bat that are dependent upon meadow ecosystems. Twenty-seven animal species of moderate vulnerability including several mammals are dependent meadows and an additional 75 species of moderate vulnerability are known to use meadow ecosystems either sometime during the lifecycle or when meadows are accessible. Several species of TES fishes occur in streams flowing through lotic meadows. Fishes are discussed in Part 4.5.2. An explanation of the vulnerability analysis and the results can be found in Appendix R.

Meadows, fens, bogs and seeps provide unique habitat for many plant species, often by providing for low-oxygen conditions and unique soil characteristics (Kattelman and Embury 1996, see also Parts 3.9 "Soil Quality" in this Chapter). Some genera of plant species such as willows, sedges and rushes are common in functioning meadows, but are sensitive to changes in hydrologic profile. These plants disappear if water tables are lowered or instream flows are altered. Approximately 30 rare vascular

plants and bryophytes are found only in meadows, or special aquatic habitat. These habitat types are critical for maintenance of populations, but in many cases the life histories of these species are not well understood. These species are identified and analyzed in Parts 4.4.

Before the arrival of Spanish and Mexican colonists, native grazing animals were present in meadows. Deer, elk, pronghorn antelope and bighorn sheep are the large ungulates native to the meadow ecosystem. These species moved in migratory patterns up and down slope with the seasons, rarely occupying single sites for long periods of time. In general it is believed that grazing of meadows by native ungulates is light (Ratliff 1985).

American Indians probably used meadows extensively. The amount and duration of the use was probably dependent upon the meadow elevation. Lower elevation meadows are accessible longer and have longer growing seasons (Anderson and Moratto 1996). Terrestrial and aquatic animals species were hunted, trapped or gathered for food. Plant fruits and grains, bulbs and foliage were gathered for food and cordage material was gathered for basketry and other fiber products. Evidence suggests that American Indians engaged in a number of land manipulation methods to enhance the presence of choice plant and animal species. Among the most obvious was the use of fire to either clear brush or encourage ruderal plant species and associated animals. Prescribed burning by Indians may have prevented invasion by trees, thus keeping them artificially open (Ratliff 1985).

Historic European-American Uses

In modern times, meadows have been very important sources of forage for livestock. Although some of the lower elevation meadows may have been converted to cropping systems, by and large meadows were, and still are, used primarily for pasturage of packstock used in transportation of supplies or recreation and grazing of sheep or cattle. Meadows are distributed through all elevations. Lower elevation meadows provide forage during winter and spring, but tend to dry out during the hot summers. High elevation meadows are not accessible until the snow melts in late spring or early summer, but provide forage during the summer and early fall. Over time ranching and recreational patterns of moving livestock to high elevation meadows during the summer evolved. Modern grazing patterns and the consequences of the alternatives are discussed in detail in the “Grazing” section, Part 5.3.

The Spanish first introduced modern ranching practices during the establishment of the missions in the 1700s. During this period cattle were valued chiefly for their hides and tallow. At this time it is estimated that the number of cattle were low, at around a quarter of a million head of animals. Herds were primarily centered on the original missions in the coastal and valley regions. Sheep were introduced later, but because of the intense labor requirements of sheep herding, the numbers remained low at around 150,000 head until the gold rush began in 1850.

As other European-Americans began pouring into California in search of gold, herds of both cattle and sheep were expanded. By 1860, an estimated 1 million head of cattle were present and the ranching centers were moving away from the coasts into the Sacramento and San Joaquin Valleys. By 1862 the number of cattle had grown to 3 million. Flocks of sheep followed a similar trend in populations and population centers. The number of sheep in California peaked in the 1870s at about 6.4 million head (Ratliff 1985).

All of this expansion, plus several years of natural disasters (floods and droughts) increased the need for suitable forage. By 1876 the practice of summer grazing in higher elevation meadows had begun.

During the early years sheep were emphasized over cattle and by most accounts it is during this time that much of the damage to the resource occurred (Ratliff 1985). In addition to the effects by the animals, sheepherders were known to set large fires in the fall to maintain open space and select for ruderal species (Menke and others 1996, Allen-Diaz and others 1999). By 1900, cattle were replacing sheep, a trend that continued until recent time. Very few herds of sheep are currently grazing meadows (Menke and others 1996). Although accounts and accounting methods conflict, in general cattle production on national forest lands in the Sierra Nevada declined from the 1920s to the 1970s (Allen-Diaz and others 1999). There is some evidence that the number of cattle were increasing in the 1970s through the 1980s (Ratliff 1985). Evidence collected during analysis for the SNFPA project indicates that meadow use by cattle is declining overall and is expected to continue in a downward trend with adoption of new forest plans. More discussion is available in the “Grazing” analysis Part 5.3.

Beginning at the turn of the century when tourism was developing in the Sierra Nevada, the use of meadows for pasturing of packstock became more prevalent (Ratliff 1985). Following World War II pack trips into the backcountry became even more popular (Allen-Diaz and others 1999). At the same time, meadows began to be popular destinations for hikers and backpackers. Recreation use of these ecosystems has the potential to produce different types of disturbances as compared to grazing. Particularly for some animal species, these kinds of disturbances such as noise, human waste and trails may be more detrimental than cattle (Graber 1996). Several conflicts among users have been identified (see Allen-Diaz and others 1999, and the references therein). In general, poorly managed packstock and large parties on backcountry trips can damage meadow resources. Dispersed camping at popular destinations can also result in increased erosion, trampling of stream banks, and water pollution.

In the mid 1960s the Forest Service and the Park Service initiated research efforts to understand meadow properties, functions and how agricultural and recreational uses impact these properties. Research continues, supported by a wide variety of public and private financial sources (Ratliff 1985, Kattelman 1996). The result of these efforts have altered approaches to grazing and placed pressure on both the Forest Service and permittees to amend grazing practices. However, the issue still remains controversial and little irrefutable evidence in support of one management direction over another exists. To characterize distributions of meadow ecosystems in the Sierra Nevada, data derived from GIS vegetation maps were analyzed. Part of this effort resulted in the information presented in Table 3.4I, however, because the data was never intended for the intense analysis necessary for the SNFPA project, the total acres should be considered a rough estimates. A similar, but more refined data set was used for evaluation of the alternatives on willow flycatcher habitat (Part 4.3.3 “Willow Flycatcher”) and it is suggested that they may be a more accurate presentation.

Table 3.4I. Distribution of meadow acres by elevation and ownership. These data were derived directly from GIS products and have not been carefully assessed for accuracy based on ground evaluations. They are presented as a basis comparative assessment of distribution.

Ownership	Elevation	Ephemeral wetland	Wet / shrubby	Wet / herbaceous	Dry / herbaceous	Dry / shrubby	Grand Total
National Forest lands	<4000	47	292	1,923	300	831	3,393
National Forest lands	4000 - 7500	22,325	35,464	19,515	1,868	15,900	95,072
National Forest lands	>7500	0	10,166	7,045	1,690	1,947	20,848
Private Inholdings	<4000	59	456	864	913	1,653	3,945
Private Inholdings	4000 - 7500	50	19,130	11,851	505	4,367	35,903
Private Inholdings	>7500	0	2,248	735	68	80	3,131
Wilderness	4000 - 7500	0	3,898	820	72	400	5,190
Wilderness	>7500	0	15,612	18,853	1,506	983	36,954
All Owners	<4000	106	748	2,787	1,213	2,484	7,338
All Owners	4000 - 7500	22,375	58,492	32,186	2,445	20,667	136,165
All Owners	>7500	0	28,026	26,633	3,264	3,010	60,933
All Owners	Total	22,481	87,266	61,606	6,922	26,161	204,436

Meadows are difficult to map, therefore the information available for analysis is incomplete. Remote sensing, including aerial photography, often fails to identify meadows embedded in mid-elevation forests, particularly small meadows one to five acres in size. For the most part, meadows are mapped as they become important for a particular resource issue. It is with this uncertainty in mind that the following data is presented.

Ephemeral wetlands are areas that do not qualify under any of the other categories, but do provide important habitat, including vernal pools and other seasonal water-dependent features. Wet shrubby meadows have some quantity of moving water, as compared to wet/herbaceous meadows, which often develop under low oxygen conditions under standing water. They are the most common. The dry meadows and meadow complexes usually have some seasonal recharge, but not obvious surface water.

Most of the mapped meadow acres are in elevations between 4,000 and 7,500 feet (Table 3.4I). Within this elevation, the Forest Service manages a little more than 70 percent of the meadow acres; 26 percent of the meadows in the mid-elevations are on private lands. National park lands were not included in this analysis. The high elevation meadows (greater than 7,500 feet) are mostly located on national forest lands (96 percent). The ownership pattern is in agreement with the data presented by the GAP analysis that indicated the Forest Service or other Federal agencies manage most ecosystems above 7,500 feet (Davis and Stoms 1996, see “Landscapes Patterns and Vegetation Dynamics” Part 3.1). The meadows in the lower elevations (less than 4,000 feet) are equally divided between private ownership and national forest lands.

Meadows below 4,000 feet are relatively rare in the Sierra Nevada (less than 4 percent of all meadow acres). Although not displayed, nearly all of these meadows are on the west side of the Sierra Nevada crest. This elevation corresponds to the Sierra foothill ecoregion and the blue oak woodlands, montane hardwood and mixed conifer hardwood ecosystems as described in Part 3.3 “Hardwood Ecosystems.” Acres of meadows at lower elevations are nearly evenly split between dry meadows and wet meadows. The wet meadows are most likely associated with special habits such as springs and seeps.

The mid-elevation meadows correspond to the yellow pine (mixed conifer) and lower edges of the lodgepole-red fire forest. The number and acres of these meadows may be under represented due to the difficulty in identifying and recognizing meadows by remote sensing techniques. The mid-elevation meadows may occur as one or two acre patches surrounding a seep, or as strings of patches along a stream course. They may also be more substantial openings in the forests created by unique combinations of geologic and hydrologic features. Mid-elevation meadows can be very important habitat for rare and endemic plant species. Recent studies indicate that they are critical habitat for several amphibian, mollusk and invertebrate species (Kattelman 1996). Many mammal and bird species also use or depend on these patches for some part of the life cycle. Approximately 83 percent of the mid-elevation meadows are classified as wet. Shrubby meadows occupy 59 percent of the wet types while herbaceous types occupy 41 percent of the meadows between 4,000 and 7,500 feet. The dry/herbaceous acres are mostly on the Modoc plateau (the Lassen and Modoc National Forests) and on eastern side of the Sierra Nevada crest (Inyo and Tahoe National Forests) (Table 3.4m).

The ephemeral wetlands contain several types of meadows that do not easily fit into the other categories, most importantly are the vernal pool ecosystems. However, these wetland types are very poorly mapped, and little is known about their distributions. Currently almost all of the acres identified in this category are on the Modoc National Forest. It is thought that other national forests also have these meadow types, but they are either miss-mapped or misidentified.

The meadow acres that occur above 7,500 feet occur in the lodgepole-red fir, subalpine and alpine ecosystems. They are nearly equally divided between wet/herbaceous and wet/shrubby meadow types. As described above, the presence or absence of shrubby species is driven primarily by the oxygen status of the soils. Standing water over long periods of time tend to favor the reeds and rushes, while running water and well drained banks favor willows and other hardwood species. The dry meadows are found mostly on the Modoc plateau and eastern side of the Sierra Nevada ecoregion (Table 3.4m).

Table 3.4m. Distribution of meadow acres by national forest and the inholding associated with national forests. The percent of each meadow type contained within the individual holdings are shown in the column to the right of the acres. Wilderness areas are managed by the forest service. The national parks are not displayed.

Ownership	Ephemeral wetland		Wet / shrubby		Wet / herbaceous		Dry / herbaceous		Dry / shrubby		Grand Total
	acres	% of col.	acres	% of col.	acres	% of col.	acres	% of col.	acres	% of col.	
Eldorado National Forest		0.0%	3,052	3.5%	1,521	2.5%	291	4.1%	212	0.8%	5,076
In-Holding Eldorado NF		0.0%	1,569	1.8%	725	1.2%	74	1.0%	64	0.2%	2,432
Inyo National Forest		0.0%	2,693	3.1%	6,228	10.1%	1,800	25.1%	1,617	6.2%	12,338
In-Holding Inyo NF		0.0%	865	1.0%	668	1.1%	68	0.9%	123	0.5%	1,724
Lassen National Forest		0.0%	14,304	16.4%	7,792	12.6%	420	5.9%	8,633	32.8%	31,149
In-Holding Lassen NF		0.0%	6,695	7.7%	6,377	10.3%	7	0.1%	2,090	8.0%	15,169
Lake Tahoe Basin MU		0.0%	8,942	10.2%	1,005	1.6%		0.0%	815	3.1%	10,762
In-Holding LTBMU		0.0%	3,798	4.3%	809	1.3%		0.0%	802	3.1%	5,409
Modoc National Forest	22,311	99.2%	3,758	4.3%	4,121	6.7%	805	11.2%	5,801	22.1%	36,796
In-Holding Modoc NF	28	0.1%	15	0.0%	53	0.1%	2	0.0%	358	1.4%	456
Sequoia National Forest		0.0%	1,502	1.7%	4,810	7.8%	2	0.0%		0.0%	6,314
In-Holding Sequoia NF		0.0%	284	0.3%	245	0.4%		0.0%		0.0%	529
Sierra National Forest	61	0.3%	1,712	2.0%	495	0.8%	77	1.1%	31	0.1%	2,376
In-Holding Sierra NF	81	0.4%	805	0.9%	437	0.7%	80	1.1%	31	0.1%	1,434
Stanislaus National Forest		0.0%	2,935	3.4%	285	0.5%	427	5.9%	406	1.5%	4,053
In-Holding Stanislaus NF		0.0%	1,488	1.7%	392	0.6%	1,187	16.5%	1,006	3.8%	4,073
Tahoe National Forest		0.0%	7,136	8.2%	2,226	3.6%	291	4.1%	1,168	4.4%	10,821
In-Holding Tahoe NF		0.0%	6,315	7.2%	3,744	6.1%	68	0.9%	1,626	6.2%	11,753
Wilderness (RSL)		0.0%	19,510	22.3%	19,673	31.9%	1,578	22.0%	1,383	5.3%	42,144
Private Lands (govt own)	1	0.0%	86	0.1%	79	0.1%	1	0.0%	118	0.4%	285
Total	22,482		87,464		61,685		7,178		26,284		205,093

The different meadow types are not distributed evenly across the national forests, including inholdings (Table 3.4m). Almost all of the ephemeral wetlands are on the Modoc National Forest, but as noted above that may be an artifact of mapping. Twenty-two percent of the wet/shrubby meadows occur in wilderness areas, followed by the Lassen National Forest with 16 percent and the Lake Tahoe Basin Management Unit. Wilderness areas also contain the largest percentage of wet/herbaceous acres (32 percent). The Inyo, Lassen, Modoc and Sequoia National Forests together contain an additional 47 percent of the wet/ herbaceous meadows, mostly in the higher elevations. The Inyo National Forest contains the greatest percentage of dry/herbaceous meadows at 25 percent. Wilderness areas (22 percent) the Modoc national forest (11 percent) and inholdings on the Stanislaus (16.5 percent) contain most of the rest of the dry/herbaceous acres. Dry/shrubby meadows are found mostly on the Lassen National Forest (33 percent), followed by the Modoc and Inyo National Forests. In-holdings on the Lassen and Tahoe National Forests contain more the 14 percent of these acres.

Table 3.4n. Meadow acres and allotment status by ownership.

Ownership	Allotment Status*	Ephemeral wetland	Wet/ shrubby	Wet/ herbaceous	Dry herbaceous	Dry/ shrubby	Grand Total
Private Inholdings	Active	55	12,009	7,501	640	3,129	23,334
Private Inholdings	Inactive	0	902	759	54	177	1,892
Private Inholdings	Not in	0	65	50	0	10	125
Private Inholdings	Not allocated	54	8,858	5,140	792	2,784	17,628
Private Inholdings	Total	109	21,834	13,450	1,486	6,100	42,979
National Forest lands	Active	21,287	33,491	20,396	3,216	16,112	94,502
National Forest lands	Inactive	945	1,843	1,247	26	429	4,490
National Forest lands	Not in	2	190	213	0	115	520
National Forest lands	Not allocated	138	10,510	6,627	871	2,028	20,174
National Forest lands	Total	22,372	46,034	28,483	4,113	18,684	119,686
Wilderness	Active	0	7,621	10,419	1,182	965	20,187
Wilderness	Inactive	0	3,253	966	347	265	4,831
Wilderness	Not in	0	31				31
Wilderness	Not allocated	0	8,605	8,288	49	153	17,095
Wilderness	Total	0	19,510	19,673	1,578	1,383	42,144
	Grand Total	22,481	87,378	61,606	7,177	26,167	204,809

*Active, Inactive, and Not in, were derived from the regional forest allotment maps. Not allocated, are meadow acres outside of the allotment map boundaries.

Grazing continues to be one of the most important human activities in meadows as described in Part 5.3. The majority of meadow acres both on national forests lands and in private management are in active grazing allotments (Table 4.3n). However, this does not mean the allotments are actively grazed, nor does it indicate the grazing pattern, such as seasonal of use or rotations. Of the private inholdings, 54 percent are in active allotments, and 41 percent are on lands not covered by the allotment maps. Not allocated lands occupy only 17 percent of the national forest lands. Seventy-nine percent of the meadow acres are in active allotments and just over 4 percent are either in inactive or not allocated acres. About half of the acres of meadows in wilderness areas are in active allotments. The remaining acres are in either inactive allotments or not allocated lands.

Special habitats associated with aquatic ecosystems, riparian corridors and meadows

The section that follows describes critical, unique ecological features or unique ecosystems unto themselves. Unfortunately, these features are generally very small and little is known about their distribution. Even less is known about their ecology. The Forest Service has very little information regarding past or present management or condition of these places. It is projected that under new management direction, these features will be better identified and additional research will aid in an increased understanding the functions of these special habitats.

Special aquatic features are unique wetlands of high biological diversity occupied by rare aquatic and terrestrial animal and plant species. These habitats attract a variety of terrestrial animals because they provide a concentrated food and water source. Special aquatic features may be sporadically distributed and uncommon compared to other habitat types associated with streams, rivers, lakes and meadow complexes. Typically, special aquatic features have unique biotic communities with a high number of endemic species (Hynes 1970, Erman and Erman 1995, Erman 1996).

Special aquatic features may represent environmental extremes with respect to water temperature, permanence, and chemistry, but they may also be stable environments, exhibiting little seasonal or annual variation. For example, cold water springs usually have a very constant year round discharge,

temperature, and water chemistry. Other examples of specialized aquatic feature types include hot springs, alkaline and caldera lakes (for example Mono Lake), fens, bogs, vernal pools, marshes, seeps, and snowmelt pools. Although special aquatic and riparian habitats contribute significantly to landscape and biological diversity, the biotic communities associated with special habitats are often poorly known. Because special habitats are often small and isolated, they are sensitive to local impacts such as water diversions, mining, roads, and recreation. Even when special habitats connect to larger meadow system or permanent water bodies, their local conditions and communities remain distinctive.

Cold springs are lotic habitats that contribute significantly to biodiversity in areas where they occur. Erman and Erman (1990,1995) surveyed 21 cold springs and their associated caddisfly fauna. They concluded that the biodiversity of cold spring fauna was highest in permanent springs with the highest discharge and calcium ion concentrations and the lowest solar radiation. Fauna of cold springs often include rare, relict, and endemic species. Since cold springs are usually habitats that have been isolated for hundreds or thousands of years, they have quite distinctive fauna. Erman and Erman (1995) found that the average similarity between caddisfly species from separate springs was only 23 percent. A majority of caddisfly species (40 of 77) collected in the their study area were present only in cold springs and spring-influenced streams.

Shepard (1993) noted that desert and eastern Sierra Nevada springs contain rich but poorly understood biodiversity. Distances of at least 12 miles typically separate them, and dispersal between spring habitats is virtually impossible for most of their inhabitants. Desert spring communities provide habitat for relictual species populations that became isolated as the climate become drier about 10,000 years ago. Although the fish species associated with springs are distinctive, invertebrates make up the great majority of the fauna. These invertebrates are microhabitat specialists. A particular species reaches its highest abundance where the combination of water depth, temperature, and velocity; substrate; and shade are most favorable. The most common aquatic invertebrates are insects, crustaceans, oligochaete worms, and mollusks. Spring snails in the family Hydrobiidae are often the most common macroinvertebrate present and may reach extremely high densities.

Fens are another poorly understood, sporadic, aquatic habitat in the Sierra Nevada. Fens are often times mischaracterized as bogs, which are actually rare in the Sierra Nevada range. Erman and Erman (1975) studied several fens in the Sagehen Creek Basin and described general patterns there that may represent conditions elsewhere in the bioregion. Fens are minerotrophic peatlands (lentic systems) which characteristically have flowing, mineral-rich water with high concentrations of calcium and magnesium ions, a pH ranging from near neutral to alkaline (pH 7.0 to 8.4), and shallow peat layers (less than 6.5 feet deep). During the summer, fens undergo fluctuations in dissolved oxygen (from 35 to 95 percent saturation), temperature (from 9.5 to 30 degrees Centigrade), and water level. Available oxygen is restricted closely to the water surface and fluctuates daily. A few dozen moss and sedge species comprise the vegetation. Plant species that occupy minerotrophic fens include bulrush (*Scirpus* spp.), blister and Nebraska sedges (*Carex* spp.), monkey flower (*Mimulus* spp.) and various mosses (*Drepanocladus* spp. and *Cratoneuron* spp.). The biotic community is limited to a few species. Most macroinvertebrates are oligochaete worms, nematodes, and aquatic flies. Water mites are often present at low abundances, and peaclams are rarely encountered.

Bogs are ombrotrophic peatlands (lentic systems) that derive water and nutrients only from the atmosphere through precipitation and air borne deposits. Bogs are highly acid and nutrient-poor and

dominated by sphagnum mosses and ericaeaceous shrubs such as Labrador tea (*Ledum* sp.) and moss heather (*Cassiope* sp.) (Chadde and others 1998). Some of the insectivorous plants such as California pitcher plant (*Darlingtonia californica*) and sundews (*Drosera* sp.) are also found in these habitats. The sphagnum mosses that exchange hydrogen ions for mineral cations in the water induce the acidic nature of bogs. Moyle (1996b) classified bogs as among the rarest of habitats in the Sierra Nevada and Modoc Plateau. Barbour and Major (1990) state that small, isolated bogs occur at high altitudes in the subalpine and headwaters zones of lakes and rivers in the southern Sierra Nevada. Bogs are easily altered by disturbance. If water should flow through this habitat or more nutrients were added from sedimentation, the acidity and vegetative composition would likely change.

Marshes in the Sierra Nevada range are classified as fresh emergent wetlands. These are lentic systems characterized by frequent flooding, upright, perennial hydrophytes and roots that are adapted to anaerobic conditions. On moist sites of the fresh emergent wetlands species such as big leaf sedge and Baltic rush dominate. While on more alkali sites, saltgrass (*Distichlis* sp.) dominates. On wetter sites, bulrushes (*Scirpus* spp.), spiked rush (*Eleocharis* spp.) and arrowhead (*Sagittaria* sp.) may dominate (Shiflet 1994).

Environmental Consequences

Methods Used to Assess Environmental Consequences

The aquatic management strategy goals (presented in Figure 2.3 in Chapter 2) describe desired conditions for aquatic, riparian, and meadow ecosystems. The Affected Environment section identified important physical and biological characteristics necessary to protect and expand aquatic, riparian and meadow ecosystems. Environmental consequences for aquatic, riparian, and meadow ecosystems are assessed by estimating the relative effectiveness of the land management activities and management direction proposed by the alternatives in meeting the goals. All of the action alternatives move ecosystem conditions toward these goals but the main difference is in the time spans required to make changes.

Not all AMS goals are completely addressed because of limits in the scope of this FEIS. For example, moving conditions toward some of these goals may require changes in how dams and diversions are operated or complex projects to restore floodplains and water tables in meadows. These are important needs that will be addressed by programs outside the scope of this FEIS. However, the other programs will use the AMS goals to provide consistent direction for ecosystem management among the national forests in the Sierra Nevada.

Effects of the Alternatives on Aquatic, Riparian, and Meadow Ecosystems

The following sections describe the environmental consequences associated with implementing the proposed alternatives for aquatic, riparian, and meadow ecosystems. This section is organized by management activities or “effectors” and discusses how the management proposed by each alternative would affect aquatic, riparian and meadow ecosystems.

Variable direct and indirect effects are projected for the alternatives. The following factors were used to evaluate the effects of the alternatives on aquatic, riparian and meadow ecosystems: (1) reduction in the risk of wildfire acres including effects from wildfire recovery and timber salvage; (2) fuel reduction activities including acres of mechanical fuel reduction treatments and acres of prescribed fire; (3) management within and designation of buffers, critical aquatic refuges, emphasis watersheds or aquatic diversity areas; (4) grazing management; (5) other management actions such as mining,

pesticide use, road management, recreation management and (6) special management requirements such as the level of landscape/watershed analysis required or development of conservation assessments for aquatic or riparian dependent species. Part 4, “Species of the Sierra Nevada” presents the effects of the alternatives on aquatic, riparian, and meadow-dependent species.

Effects Related to Wildfire Risk

Proposed activities for reducing amounts of forest fuels have the potential for significant aquatic and water quality impacts. However, high severity wildfires pose a far greater risk of damaging aquatic systems due to their great areal extent (Kattelman 1996). As discussed in Part 3.5. “Fire and Fuels: Affected Environment,” increased accumulation of forest fuels over the past century has contributed to a trend of increasing fire severity. Over the last 30 years an average of 47,000 acres in the Sierra Nevada have experienced wildfires. However, in the past decade this average has increased to approximately 76,000 acres.

When high severity wildfires occur in high fuel loading conditions at lower elevations, changes in the site capability may favor dominance by fire-adapted shrub communities. Following high severity wildfire it may take several decades for reforestation to occur either naturally or by silvicultural methods where tree seedlings are planted. It can also take several decades for watersheds, riparian areas, and aquatic ecosystems to recover. Wildfire effects to riparian vegetation are primarily concentrated in seasonal rather than perennial streams because of the drier conditions that occur in these areas. However, the proportion of seasonal streams to perennials is high, thus effects within seasonal drainages could be magnified in perennial streams.

The adverse effects from high severity wildfire include increased sedimentation of streams by soils eroded from both uplands and stream banks. In steep areas, loss of live roots from fire-killed vegetation may sufficiently reduce slope strength to cause landslides into stream channels. Storm and snowmelt runoff may substantially increase in severely burned watersheds due to the reduced infiltration capacity of the soil caused by physical changes in surface soils from excessive heating during the fire (DeBano and others 1979, DeBano 1981, Poff 1996). Increased runoff together with reduced soil cover by vegetation and litter may accelerate erosion across the landscape. In severely burned watersheds of several hundred acres or more, peak streamflows may increase locally resulting in accelerated channel bank erosion.

As shown in the Comparison of Alternatives Table in Chapter 2, the management actions proposed in Alternatives 3,4, 6, 7,8 and Modified 8 are expected to reduce the number of acres burned in wildfires over the next 50 years. Implementation of Alternatives 8 or Modified 8 would result in a reduction of six and fifteen percent respectively. Implementation of Alternative 3,4, or 6 would result in reductions of approximately 35 percent. Implementation of Alternatives 1,2, and 5 would result in an increase in wildfire acres compared to the past 10 years ranging from a minimal increase of two and four percent for Alternative 1 and 2 to an increase of 10 percent for Alternative 5. The number of acres burned would remain above the 10 year average for Alternative 2, above the 30 year average for Alternatives 1, 5, 8, and modified 8 and return to or just below the 30-year average for alternatives 3, 4 and 6.

The watershed condition analyses presented in the Affected Environment portion of this section showed that wildfire is a major effector of the aquatic and riparian ecosystems. Many of the watersheds with high activity levels were in that category due to wildfire and subsequent salvage activities. The trend analysis also showed that the major effector of the landscape was wildfire.

Alternatives 3, 4, and 6 are expected to provide the greatest protection against the detrimental effects of wildfire on riparian plant and animal communities. The management activities proposed in these alternatives should reduce the acreage affected by wildfires back to the 30-year average. Alternative 8 and modified 8 would provide intermediate protection, reducing average annual acres burned to around 60,000 acres. Alternatives 1, 2, and 5 could result in an increase in detrimental effects to the riparian and aquatic communities since the average acreage burned would remain near the past 10 year average or slightly increase. This level of increase predicted is an important factor to consider. It probably means that in years of high wildfire occurrence, the acreage of high severity fire that is most damaging to watersheds will expand. In Alternatives 1, 2, and 5 this pattern would be expected because fuel loadings would continue to increase at a faster rate than treatments could provide effective fuel reductions to reduce wildfire occurrence.

Wildfire Salvage Logging. One of the effects associated with catastrophic wildfires is the treatment of fire killed vegetation. There is a balance between the removal and retention of fire-killed vegetation. Riparian areas are of particular concern because of their ecological importance and their sensitivity to disturbance. Fire-killed trees represent a source of large woody debris that is important for stream structure. Removal of this material deprives the aquatic system of its future supply of large wood and increases ground-disturbing impacts from heavy equipment yarding logs. As trees fall, they provide microclimates that foster tree seedling survival and growth, both for natural and planted conifer seedlings. The sprouting shrubs maintain root masses necessary to hold and bind soils. Some of these shrub and perennial species (for example *Ceanothus* and *Alnus*) remove nitrogen from the air and replenish lost soil nitrogen from the fire, making it available to many plants including young conifer seedlings.

Another view of salvage and post-fire restoration is that the excess accumulation of large woody material from fallen snags may create logjams that divert flows from existing stream channels. The diverted flows cause bank erosion that potentially adds high volumes of sediment into the flowing portion of stream channels and then into downstream reaches. If an abundance of standing dead material is left, the standing snags eventually fall, creating large amounts of dead and down trees that might present a future wildfire hazard. If left untreated, shrubs would dominate the vegetation in some areas and the establishment of new forest cover would be delayed. More study is needed to address restoration and recovery of riparian areas after high severity fire.

Since post fire salvage activities are directly related to the occurrence of wildfire, the alternatives that have the risk of developing the largest and most intense fires would have the greatest potential to impact the aquatic and riparian area from harvest activities. Alternatives 3, 4, 6, and 7 have the potential to generate the fewest salvage acres, Alternatives 1, 2, and 5 the most, and Alternatives 8 and Modified 8 a level somewhat less than Alternative 1.

The level of salvage activities allowed differs by alternative. Unless conducted to protect public health and safety, salvage activities would be prohibited within the green zone of Alternative 2 and within all stream buffers in Alternative 8. Salvage activities under Alternatives 4 would be limited by cumulative effect considerations. Salvage under Alternatives 6 and 7 would be prohibited within the Riparian Conservation Zone unless the activity benefited the riparian community. Salvage would be allowed in the outer portion of the Riparian Conservation Area buffer in Alternatives 6 and 7. Alternatives 3, 5, and Modified 8 require assessments to show the consistency of the salvage activity

with the improvement of values associated with the riparian zone. This includes an assessment of the need for the retention of large woody debris on site.

In terms of acres treated, since Alternatives 3, 4, 6, and 7 reduce the risk of wildfire, there would probably be fewer acres ever treated by fire salvage. While Alternatives 2, 5 and 8 have a higher risk of wildfire, they limit the removal of fire killed vegetation. Thus it is likely that there might not be a substantial difference between alternatives in effects from salvage activities following wildfire. The only exception would be Alternative 1 which has an increased risk of wildfire but no restrictions other than an individual Forest's current LRMP, which in most Forests does not restrict salvage operations substantially in stream buffer.

All alternatives anticipate the need for restoration through burned area emergency rehabilitation projects and timber salvage. Where landscape/watershed analysis has been completed, identified desired conditions should be considered as activities are planned. Implementation and effectiveness monitoring would be needed to evaluate the efficacy of these treatments, and to improve knowledge for future projects.

Effects of Fuel Management Treatments

All of the alternatives emphasize treating fuels in urban areas and high fire hazard and risk areas first. High fire hazard and risk areas are generally located at less than 6,000 feet in elevation and occur on the upper two-thirds of slopes. In Alternatives 4, 6, 7, and 8 strategically placed area treatments (SPLATs) would be implemented. The purpose of SPLATs is to limit the extent of wildfire spread and severity, thus fires should be smaller and less damaging to the soil and vegetative resources resulting in less erosion.

Fuel reduction activities would be accomplished either through prescribed burning, mechanical removal of fuels or a combination of the two. The alternatives propose differing combinations of fuel management activities. As shown in the Comparison of Alternatives Table in Chapter 2, mechanical treatments in the first decade range from approximately 7,000 acres per year to over 85,000 acres per year. Prescribed fire treatments range from approximately 15,000 acres per year to over 80,000 acres per year. Since the purpose of fuels reduction is to reduce the risk of wildfire, it follows that the alternatives that have the greatest reduction in wildfire acres burned also have the greatest number of acres treated for fuels,

Prescribed Fire. Due to the controlled nature of prescribed fire in terms of fuel moisture, weather conditions, time of day, spatial pattern of ignition, and other factors, the impacts to soils and vegetation by prescribed fire treatments are considerably less than high severity wildfire. None of the action alternatives permit ignition of prescribed fires within areas that are primarily composed of riparian vegetation. Prescribed fire may occasionally back into riparian areas along perennial and intermittent streams from fires focused on upland areas. Prescribed fire may be used when deemed beneficial for specific restoration projects such as restoration of Aspen or rare or sensitive riparian plant species.

The strategically placed area treatments (SPLATs) are focused on areas that are away from perennial and intermittent streams on the upper two-thirds of slopes. These areas have historically had high fire frequencies and have experienced misses in the greatest number of fire cycles as a result of suppression in this century. By contrast, perennial and intermittent streams' riparian areas generally have lower fire frequency and lower priority for fuel reduction treatments.

The low intensity of these burns should retain a portion of the duff layer that would help to prevent soil erosion and leave sufficient live vegetation for rapid recovery of vegetative structure and composition. In contrast to high severity wildfire impacts, infiltration rates should not be greatly reduced and conditions causing overland flow should be avoided as a result of applying prescribed fire treatments. Without overland flow, movement of soils into stream channels is limited to soil creep, and ravel on steep slopes, at rates only slightly higher than areas not receiving prescribed fire. The risk of sedimentation and effects to water quality from prescribed fire in general would be small for each of the action alternatives regardless of the difference in acres burned. Thus, prescribed fire use in any of the alternatives would not be expected to substantively affect riparian, wetland, and meadow plant and animal communities. The alternatives would not appreciably differ in their predicted effects.

Mechanical Treatments. Mechanical fuel reduction treatments would be primarily used in areas where prescribed fire is impractical due to the density of vegetation or the size of material that needs to be removed. As noted in the Affected Environment section above, McGurk and Fong's review of research on the impact of timber harvest related activities found that the risk of negatively impacting water quality decreased as the distance from streams increased. The research they presented showed that when timber harvest related activities within 300 feet of a stream compacted more than five percent of the area, there was a significant reduction in the population of sediment intolerant aquatic invertebrates.

The levels and types of mechanical fuel reduction treatments vary by alternative as shown in the Comparison of Alternatives Table in Chapter 2. Alternatives 7 and Modified 8 propose to treat about the same number of acres that are currently treated per year as shown in Alternative 1, or about 70,000 acres. Alternative 4 proposes the highest number of mechanically treated acres; about twenty percent more acres would be treated per year than is currently treated. Alternatives 3 and 6 would treat about fifty percent fewer acres than is currently treated, Alternatives 2 and 5 would treat about ninety percent less and Alternative 8 would treat about 80 percent less.

Since all alternatives prescribe either stream buffers or limits to ground disturbing activities, the likelihood of impact from sediment to the aquatic and riparian community is small. The risk of accelerated erosion or altering soil conditions from mechanical fuel reduction treatments varies depending on factors such as total acres treated, method of treatment, type of equipment used, amount and type of materials being yarded or piled, soil type, soil moisture conditions, slope steepness, and history of past disturbance. The primary potential source area for sediment would be ephemeral channels, skidroads, and the immediate areas near them. These effects would be evaluated for each project in site-specific NEPA analysis. The Soil Quality Standards included in this FEIS are designed to minimize the disturbance to the soil resource and prevent accelerated erosion.

Mechanical fuel reduction activities are allowed along ephemeral drainages in Alternatives 3 through Modified 8 to allow effective placement of the fuel area treatments (SPLATs and DFPZs) as continuous units of treatment. Emphasis is given to protection of channel banks from disturbance in falling and yarding operations. Mechanical fuels treatments applying the SPLATs design would not be possible in Alternative 2, because restrictions on entry into the extensive network of ephemeral streams will present barriers to continuous treatment areas of 500 to 1,000 acres.

A limited water quality concern relates to disturbed soils and the potential for erosion from areas adjacent to the ephemeral channels for Alternatives 3 through Modified 8. Disturbed soils produce

sediments that flush downstream during spring snowmelt or fall rains. In Modified Alternative 8, ground disturbing activities (activities that either compact or displace the soil) would be limited to five percent of the Riparian Conservation Area. The use of mechanical fuel reduction treatments is generally limited to slopes less than 30 percent. This slope limitation will also reduce the potential for erosion from land disturbing activities on the steeper areas near ephemeral streams.

Riparian area standards and guidelines that limit activities near riparian areas would provide further protection. Each alternative proposes buffers of varying widths around aquatic and riparian areas. Alternatives 2, 3, 4, and 5 propose Variable Width Riparian areas that are established using the approach described in the SNEP Report (Kondolf et al, 1996, Erman et al 1996, and Menning et al, 1996). Riparian areas would be delineated for streams and drainages that have the beginning of a defined channel as evidenced by the presence of scour to all points downstream. These buffers would vary in width depending on various factors including soil type and topography. The inner or “green” zone, analogous to the community zone discussed in the Affected Environment section, would be at least 150 feet wide and would be set at the project level depending on the habitat needs of the resident riparian or aquatic species.

Upslope of the “green” zone, a “gray” zone, analogous to the energy zone would be delineated. This zone would also be variable in width and set at the project level based on upland conditions such as soil type and slope. Activities within the “green” zone would be prohibited in Alternative 2, limited to those that restore or maintain habitat conditions for the resident species as shown by a landscape level assessment for Alternatives 3 and 5, and allowed to occur in Alternative 4 up to the threshold set in a cumulative watershed effects analysis. Activities within the gray zone would be similarly limited.

Alternatives 6, 7, 8, and Modified 8 proposed fixed width zones based on the presence of water. Perennial streams and special aquatic features would have 300-foot wide buffers on each side of the stream. In Alternatives 6, 7, and 8 seasonally flowing streams that support riparian vegetation would have 100-foot wide buffers on each side of the stream. In Modified Alternative 8, seasonally flowing streams include all drainages with a defined channel and signs of scour and have 150-foot wide buffers on both sides of the stream. Buffers on the remaining ephemeral drainages are set at the project level.

Activities are prohibited within all buffers in Alternative 8. Activities within 150 feet of perennial streams and 50 feet of seasonal stream (Riparian Conservation Protection Zones) in Alternatives 6 and 7 must be shown to benefit the riparian or aquatic area. In Modified 8, all proposed activities within buffers must be assessed to determine whether they are consistent with Riparian Conservation Objectives.

Based on the above descriptions of activities within stream buffers, there would be no opportunities for mechanical treatment of fuels within these areas in Alternatives 2 and 8, limited opportunities in Alternatives 3 and 5, the most opportunities under Alternative 4 depending on existing conditions, and intermediate level of opportunities in the remaining alternatives.

Applying the principle that the more acres treated by mechanical methods, the higher the risk of entailing cumulative watershed effects, Alternative 2 would have the least effect on the aquatic and riparian community and Alternative 4 the greatest effect. However this principle ignores many factors that have been found to be related to negative watershed effects. Three factors are key to the

examination of cumulative effects: the nearness of the impact to the water course (McGurk and Fong, 1995), the amount and size of material removed (Erman and Erman, 2000) and the presence of roads (Furniss et al, 1991) Using these criteria, all of the alternatives except 1 and 4 probably have similar consequences. Alternative 4 would have higher consequences since it allows the entire watershed including the stream buffer to be disturbed to its threshold value rather than limiting disturbance within the stream buffers. However as discussed in the summary below, the effects of mechanical treatment need to be weighed against the risk of catastrophic wildfire.

Effects Associated with Livestock Grazing. The alternatives vary in the application of standards and guidelines that apply to plant utilization by livestock in meadow and riparian pastures. The purpose of these standards and guidelines is to reduce erosion of meadows and streambanks through the growth of stabilizing vegetation and to improve aquatic habitats by increasing the number and size of woody shrubs along streams. This should result in the reduction of sediment loading into streams for most flow regimes and may also reduce summer stream temperatures as woody vegetation along streambanks provides increasing levels of shade. All action alternatives, provide protection for riparian, wetland and meadow plant and animal communities over and above existing direction which would continue if Alternative 1 were selected.

The alternatives vary with respect to how allowable utilization of grass and grass-like forage by livestock in meadows will be determined. Alternatives 2, 6, 8 and Modified 8 require monitoring of meadow conditions to ensure that utilization of forage by livestock does not exceed 30 to 45 percent, with a higher level allowed where meadow conditions are in good to excellent condition.

Alternatives 4 and 7 rely on the professional judgment of local managers to determine if utilization levels of grasses and grass-like plants are appropriate to maintain good meadow conditions.

Alternatives 5 and Modified 8 also includes stubble height requirements besides utilization standards to ensure habitat for meadow dwelling species is maintained

Alternative 6 would require rest from grazing when managers determined meadows were in a degraded condition as defined by the USFS California Region Range Handbook; this would not require a waiting period of 3 to 5 years. Alternative 5 is the most restrictive in limiting stream bank trampling to a maximum of 5 percent for a stream reach. Alternative 8 is the next most protective, limiting streambank trampling to 10 percent. The remaining alternatives limit streambank disturbance to 20 percent.

Under Alternatives 2, 4, 6, 7, 8, and Modified 8, allotments would be monitored to ensure that utilization of shrubs does not exceed 20 percent of shrub basal stems and annual leader growth. This should protect plant vigor, promote recruitment of young riparian deciduous shrubs and support the functions of woody vegetation in providing cover and shade, and inhibiting erosion of riparian soils. Alternative Modified 8 also requires monitoring to ensure that eighty percent of new, young shrubs are retained. Alternative 5 requires that at least 50 percent of foliar density in the lower portions of all shrubs be maintained. Maintaining foliar density is important for supporting plant vigor and the recruitment of young riparian deciduous shrubs

Alternative 3 would prevent livestock grazing within a 100-foot buffer on each side of streams in suitable willow flycatcher habitat; livestock activities in riparian areas would be managed in cooperation with grazing permittees to restrict access to green and gray zones. The limited operating periods for grazing proposed by Alternatives 8 and Modified 8 to protect amphibians and willow flycatchers would also benefit riparian habitats

New livestock handling and management facilities would be prohibited in riparian areas and existing facilities would be removed from riparian areas in Alternative 3. Alternative Modified 8 would require that existing facilities be evaluated for consistency with Riparian Conservation Objectives and would not allow new facilities in riparian area. Alternatives 6, 7, and 8 direct managers to evaluate and consider prohibition or removal of livestock facilities also. Under these alternatives, installation of off-channel water devices, fencing, or other means would be considered to restrict access to riparian areas by livestock. These measures should help to protect riparian plant and animal habitats and communities.

These standards and guidelines indirectly affect water quality by limiting the numbers and time that livestock are in proximity to water bodies and the surrounding riparian vegetation. Additionally, special habitat areas for meadow dependent birds and amphibians in some of the alternatives would also remove the potential for livestock grazing effects to water quality.

Alternative 5 requires the greatest change in range management practices, followed by Alternative 8 and Modified 8. These changes would result in the fastest restoration of meadow habitats. Alternative 2, 3, and 6 would result in a positive change also but may not achieve the same rate of change as 5, 8, and Modified 8. Alternatives 4 and 7 provide the greatest flexibility in management of livestock grazing since decisions are left to the discretion of local managers. The success of this approach could vary by unit, depending on the effectiveness of local managers in monitoring habitat conditions consistently. The lack of clearly defined standards leads to the conclusion that Alternatives 4 and 7 would have the lowest certainty for maintaining and restoring riparian, wetland and meadow plant and animal community diversity.

Effects Associated with Mining Alternatives 2, 6, 8 and modified 8 identify critical aquatic refuges based on the presence of the best remaining populations of native fish and amphibians. Alternative 5 identifies critical refuges based on the same criteria; however, critical refuges also include areas outside of national forests using designations for watersheds identified by Moyle (1996) and Williams and Spooner (1998). These four alternatives (2, 5, 6, 8 and Modified 8) propose that critical aquatic refuges and critical refuges be studied for withdrawal from future minerals activities. Such withdrawals would prevent impacts to riparian vegetation associated with activities, such as road building and direct vegetation removal at the mine site. Alternative 5 also proposes withdrawal of all riparian areas from mining activities. However, withdrawal of an area from mineral development does not remove existing claims. Most mineral areas within the Sierra are already in claims and withdrawal would have little impact in the near future.

All of the action alternatives have standards and guidelines to protect riparian areas from mining impacts and mitigate mining impacts in riparian areas. The AMS goals also provide direction to aid in the development of operation plans for new mining claims. Protection of riparian vegetation would be a part of this direction. Standard and guidelines specifically limits the clearing of trees and other riparian vegetation associated with mining activities. Alternative 3 would provide even stronger protection since mining facilities and constructed access roads would be located outside of riparian areas. Where this was infeasible, managers would consider mineral withdrawals.

Since the standards and guidelines for mining are common to all alternatives, except for the provision mentioned above in Alternative 3, there would be no difference among the alternatives in the

immediate future. The proposed standards and guidelines would provide cleared direction to forests for management of claims within riparian areas and should result in fewer impacts.

Effects associated with the Management of Roads. Road management does not fundamentally vary by alternative. Although road building has had and can have a pervasive influence on aquatic and riparian ecosystems and water quality, the standards and guidelines recommended for implementation with this FEIS should improve the existing road system and lower the effects of roads on the aquatic and riparian environments. New road construction is projected to be minimal and road decommissioning and improved maintenance are emphasized. National policy included in the Roads rule will require the assessment of all National Forest roads over the next 10 years. Alternative Modified 8 requires all NFS roads within the SNFPA be assessed and prioritized for restoration, maintenance, or decommissioning within the next 5 years. Thus Alternative Modified 8 performs slightly better than the other alternatives since road related impacts to the riparian and aquatic ecosystem will be discovered and scheduled for rehabilitation sooner.

Effects associated with Pesticide Use. The potential for severe infestations of noxious weeds such as yellow star thistle, spotted knapweed, tamarisk, Spanish broom, and others can disrupt plant communities and the ecosystems connected to them. Noxious weed control relies on an integrated approach to relate the weed's life history and sensitivities to the ecosystems it is invading. Use of herbicides is usually a choice of last resort. For yellow star thistle and spotted knapweed, control is elusive without herbicide use. Current infestations can be treated by ground application. Common herbicides for yellow star thistle include, clopyralid, triclopyr, and glyphosate. Yellow star thistle may invade riparian areas in hardwood riparian areas at lower elevations, openings in forests, and in meadows at middle to higher elevations. It is believed that prudent control measures taken in the next few years can prevent widespread infestation throughout the Sierra Nevada.

In recent years Forests have applied herbicide treatments in areas that were severely burned from catastrophic wildfires to control sprouting of hardwood shrubs. The chemicals of choice have been hexazinone, glyphosate, and triclopyr. The decisions to apply these chemicals were made after studies and analysis in compliance with NEPA (National Environmental Policy Act). Aerial and ground applications were made depending on the area of treatment. These treatments were made to reduce competition to planted conifer seedlings in the effort to reforest these areas and control plant competition and eventual dominance by the shrubs. Sampling of water quality was conducted in the streams draining the treatment areas to detect overspray and runoff of the chemicals immediately following the herbicide applications. Herbicide detection in stream waters was rare and was well below concentration levels of concern (pers comm. J.Frazier, Stanislaus NF, 4/21/99, Dave Bakke, Pacific Southwest Region Pesticide coordinator). The control objectives for the projects were achieved over most of the area of treatment. Similar projects are likely to be proposed following future high severity fire areas to meet similar objectives for reforestation.

All of the action alternatives recommend avoidance of the application of pesticides within stream buffers. Known and occupied sites for amphibians are a particular concern since recent studies show that amphibians may be susceptible to genetic damage from organo- or chloro- type pesticides. Project level environmental analyses would be conducted when herbicides were selected for treatment of infestations of noxious weeds. Chemicals would be kept from water bodies and applied directly to individual plants. With these and additional safeguards, noxious weed suppression projects would be expected to proceed without harm to the aquatic and riparian environment. There would be no difference among the alternatives with respect to the use of pesticides within stream buffers.

Other Management Actions. All of the alternatives require some level of review and potential modification of recreational activities within buffers. Most of the alternatives require that existing recreational facilities be reviewed for consistency with the goals of the AMS. Off Highway vehicle use would be restricted to roads and trails in all action alternatives. Dispersed camping would be effectively prohibited in buffers in all of the Alternatives since there needs to be a demonstrated benefit to the riparian resources.

Several broad scale actions are specifically identified in Alternative Modified 8 to help meet the goals of the AMS. These actions include the development of appropriate Conservation Plans with other state and federal agencies for vulnerable plant and animal riparian/aquatic dependent species, implementation of relevant recovery plans for aquatic/riparian dependent threatened or endangered species, and actions to minimize habitat degradation of vulnerable species.

Alternatives 3, 5, and Modified 8 require the completion of landscape analyses across the landscape to inform management decisions. Alternative Modified 8 requires that the analysis be completed across the entire SNFPA within 5 years. Alternatives 3 and 5 require the analysis prior to the planning and implementation of management activities. Landscape analysis is suggested as a tool in the other action alternatives. Modified Alternative 8 also includes a peer review process to ensure that standards and guidelines are properly applied.

Alternatives 2, 5, 6, 8, and Modified 8 set aside blocks of land called critical refuges or critical aquatic refuges dedicated to the restoration and maintenance of habitat requirements for aquatic and riparian dependent species. Alternative Modified 8 set aside the largest acreage followed by Alternative 5 then Alternative 6 and 8.

Summary of Effects to Aquatic, Riparian and Meadow Ecosystems

The greatest effector on the landscape will either be mechanical fuel treatments or catastrophic wildfires. The other effectors described above will either affect only specific sections of the landscape such as meadows or their affects are constant across alternatives. When the balance between fuels treatment acres and risk of catastrophic wildfire is assessed, alternative that lower the risk of fire and have medium levels of treatment propose the least risk to aquatic and riparian systems. This means that Alternatives 3, 6, and Modified 8 are expected to pose the least risk of negatively impacting riparian and aquatic ecosystems, Alternatives 4 and 7 an intermediate level; and Alternatives 1, 2, 5, and 8 the highest.

Another consideration is the size of material removed and the retention requirements for forest stands. Large openings were found by Erman and Erman (2000) to negatively affect the microclimate of the riparian zone. This means that alternatives that remove smaller material and require higher crown closures will have a greater benefit to the aquatic and riparian ecosystem. Using these criteria, Alternatives 2, 5, 8 and Modified 8 would have the least impact. However, the risk of catastrophic wildfire, which would have a profound effect on forest openings is high in Alternatives 2 and 5. Thus Alternatives 8 and Modified 8 would have the least overall impact on long term forest structure surrounding riparian areas.

Other factors such as the requirement for landscape analysis, peer reviews, and special protection for sensitive species also are hallmarks of alternatives that will provide increased protection for the aquatic and riparian ecosystems. Alternatives 3, 5, and Modified 8 all require landscape assessment.

Only Alternative Modified 8 requires the analysis to be completed across the entire SNFPA. These analyses will provide important context to management decisions and allow decisions to consider impacts to and needs of species outside of the immediate project area. The Conservation Assessments completed under Alternative Modified 8 will inform management decisions in all aquatic and riparian habitats. It will provide some of the basic information needed to better manage habitats for these species. The creation of Critical Refuges in Alternative 5 and Critical Aquatic Refuges in Alternative 2, 6, 8 and Modified 8 will also provide special protection for sensitive species. The conservation assessments and refuges are important first steps in the development of conservation management strategies for aquatic and riparian dependent species.

Based on all of the above factors, Alternative Modified 8 best protects the values associated with aquatic and riparian habitats. It is closely followed by Alternatives 3 and 6. The other alternatives have pluses and minuses in their ability to protect riparian and aquatic values. While Alternatives 4 and 7 reduce the risk of wildfire, they lack specific guidance that would provide protection to aquatic and riparian species. On the other hand, Alternative 2, 5, and 8 provide protective management measures, they also pose the highest risk of catastrophic wildfire. Alternative 1 provides the least protection for aquatic and riparian values.